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NASA-TM-X-62265(2) A SIMULATOR
INVESTIGATION OF THE INFLUENCE OF ENGINE
RESPONSE CHARACTERISTICS ON THE APPROACH
AND LANDING FOR AN EXTERNALLY BLOWN FLAP
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**A SIMULATOR INVESTIGATION OF THE INFLUENCE OF ENGINE
RESPONSE CHARACTERISTICS ON THE APPROACH AND LANDING
FOR AN EXTERNALLY BLOWN FLAP AIRCRAFT**

Part 2: Aerodynamic Model

Donald L. Ciffone and Glenn H. Robinson

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A SIMULATOR INVESTIGATION OF THE INFLUENCE OF ENGINE
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The following is a description of the aerodynamic model of the aircraft used in the simulation study discussed in Part 1 of this report. The model was based on an externally blown flap aircraft with engines mounted at 0.22 and 0.42 semispan.

The wing incorporated blown leading edge flaps, which were deflected 60 degrees, and 0.62 semispan triple-slotted trailing edge flaps. The trailing-edge flaps were divided into two spanwise segments on each wing semispan. The outer third of each semispan consisted of a 30 degree drooped aileron with 60 degree maximum deflection. Wing spoilers of 0.57 semispan (located directly in front of the ailerons and outboard half of the flaps) with maximum deflection of 60 degrees were also used for roll control. The aft segment of the inboard flap could be deflected symmetrically as a drag control device. The aft segment of the outboard flap could be deflected asymmetrically for roll control.

The horizontal stabilizer was used for longitudinal control. It incorporated a leading edge Kruger flap and a geared elevator such that at maximum stabilizer deflections of ± 10 degrees, the elevator was deflected $+10$ and -50 degrees respectively. The vertical stabilizer employed a 0.57 chord double hinger rudder for directional control.

Aerodynamic characteristics as a function of angle of attack, thrust coefficient, and flap deflection are presented in Tables AI through AXV and Figures A1 through A50. Static longitudinal data are referred to the stability-axis system. The dynamic longitudinal and lateral-directional data and static lateral data are referred to the body-axis system. A listing of the individual tables and figures follows. Only data for flap deflections of 35 and 60 degrees are included herein. Data for the flaps up and 40 degree flap configurations were used in addition to the 35 and 60 degree flap data in the complete aerodynamic model for the simulation.

In conclusion, the authors wish to express their appreciation to Messrs. D. A. Kier and B. G. Powers of the Flight Research Center and W. D. Grantham of the Langley Research Center for making available the aerodynamic data in their individual simulations as an aid in the compilation of the simulation model reported herein.

LIST OF TABLES

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Table	δf_3 deg	C_j	Effect of Angle of Attack on The Coefficient of:
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AIII	35, 60	0., 1.94, 3.50	Rate of change of lift with spoiler deflection
AIV	35, 60	0., 1.94, 3.50	Rate of change of drag with spoiler deflection
AV	35, 60	0., 1.94, 3.50	Rate of change of side force with spoiler deflection
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AVII	35, 70	0., 1.74, 3.48	Side force due to yaw
AVIII	35, 60	0., 1.94, 3.50	Rate of change of yawing moment with spoiler deflection
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AX	35, 60	0., 1.94, 3.50	Rate of change of rolling moment with spoiler deflection
AXI	35, 60	0., 1.59, 3.18	Rate of change of rolling moment with aileron deflection
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AXII	35, 70	0., 1.89, 3.78	Ratio of lift in ground effect to lift in free air
AXIII	35, 70	0., 1.89, 3.78	Drag coefficient increment due to ground effect
AXIV	35, 70	0., 1.89, 3.78	Pitching moment increment due to ground effect
Table	δf_3 deg	C_j	
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Figure	δf_3 deg	Effect of Thrust Coefficient ($C_j = 0., .97, 1.93, 2.9, 3.85$) and Angle of Attack on The Coefficient of:
A1, A2 A3, A4	35, 60	Lift Rate of change of lift with stabilizer deflection (includes δ_e)
A5, A6		Rate of change of lift with deflection of aft element of inboard segment of trailing edge flap (Δf_3)
A7, A8 A9, A10		Drag Rate of change of drag with stabilizer deflection (includes δ_e)
A11, A12		Rate of change of drag with deflection of aft element of inboard segment of trailing edge flap (Δf_3)
A13, A14 A15, A16		Pitching moment Rate of change of pitching moment with stabilizer deflection (includes δ_e)
A17, A18		Rate of change of pitching moment with deflection of aft element of inboard segment of trailing edge flap (Δf_3)
A19, A20		Damping in pitch (includes $C_{m\dot{\alpha}}$)
A21, A22 A23, A24 A25, A26		Rate of change of side force with side slip angle Rate of change of side force with rudder deflection Rate of change of side force with differential deflection of aft element of outboard segment of trailing edge flap (Δf_3)
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A33, A34		Yawing moment due to roll
A35, A36		Damping in yaw
A37, A38 A39, A40 A41, A42 A43, A44		Yawing moment increment due to outboard engine out Rate of change of rolling moment with rudder deflection Rate of change of rolling moment with side slip angle Rate of change of rolling moment with differential deflection of aft element of outboard segment of trailing edge flap (Δf_3)
A45, A46 A47, A48 A49, A50		Damping in roll Rolling moment due to yaw Rolling moment increment due to outboard engine out

C_{NQ}						
δ_{F_3}	35°			70°		
$\begin{array}{c} C_j \\ \diagdown \\ \infty \end{array}$	0.	1.74	3.48	0.	1.74	3.48
-10°	-10.	+25.	30.	8.	25.	25.
-2	+12.	32.	37.	14.	33.	35.
+6	28.	37.	43.	27.	40.	40.
12	41.	42.	46.	40.	37.	40.
18	48.	63.	48.	43.	85.	41.
24	41.	79.	63.	35.	105.	125.
28	37.	75.	80.	31.	92.	135.

Table AII

		$C_{L\delta_{SP}}$					
δ_{F_3}		35°			60°		
∞	C_j	0.	1.94	3.50	0.	1.94	3.50
-10°		-.0087	-.0065	-.0058	0.	-.01	-.0017
-2		-.0087	-.0065	-.0058	-.0042	-.0067	-.0033
+6		-.0087	-.0088	-.005	-.0067	-.0083	-.005
12		-.0078	-.0075	-.0038	-.0083	-.0133	-.0067
18		-.0027	-.0045	-.0030	-.0017	-.0133	-.0092
24		-.0003	-.0010	-.0020	-.0017	-.0133	-.0150
28		+.0005	+.0017	-.0007	-.0008	-.0017	-.020

Table AIII

$C_{D_{SP}}$						
δ_{F_3}	35°			60°		
α \backslash C_j	0.	1.94	3.50	0.	1.94	3.50
-10°	.0023	.0025	.0032	0.	0.	0.
-2	.0023	.0025	.0032	0.	0.	0.
+6	.0012	.0017	.0025	0.	-.0008	-.0008
12	.0005	.0013	.0019	0.	-.0017	-.0017
18	0.	.0008	.0013	0.	-.0042	-.0017
24	-.0003	-.0005	+.0006	0.	-.0042	-.0067
28	-.0002	-.0003	+.0006	0.	-.0017	-.0075

Table AIV

		$C_{y_{\delta_{SP}}}$					
δ_{F_3}		35°			60°		
∞	C_j	0.	1.94	3.50	0.	1.94	3.50
-10°		-.0017	-.0003	+.0021	-.0007	-.0013	-.0023
-2		-.0017	-.0002	+.0012	-.0017	-.0022	-.0026
+6		-.0022	-.0003	+.0005	-.0015	-.0033	-.0033
12		-.0020	-.0007	+.0003	-.0010	-.0045	-.0043
18		-.0015	-.0007	+.0003	-.0003	-.0053	-.0050
24		-.0015	-.0005	+.0004	+.0002	-.0070	-.0065
28		-.0012	-.0003	+.0004	.0002	+.0002	-.0095

Table AV

		C_{y_p}					
δ_{F_3}		35°			70°		
∞	C_j	0.	1.74	3.48	0.	1.74	3.48
-10°		-0.20	-0.50	-0.27	-0.20	+0.05	-0.30
-2		-0.14	-0.09	-0.02	-0.16	0.	-0.18
+6		+0.04	+0.17	+1.70	0.	+0.18	+0.20
12		0.10	0.37	0.41	0.07	0.40	0.56
18		0.11	0.41	0.59	0.10	0.55	0.92
24		0.02	0.50	0.62	0.08	0.15	1.11
28		0.02	0.55	0.72	0.02	0.40	0.38

Table AVI

		C_{Y_R}					
δ_{F_3}		35°			70°		
α	C_j	0.	1.74	3.48	0.	1.74	3.48
-10°		0.75	0.	0.40	1.26	0.70	1.32
-2		0.61	0.55	0.81	0.80	0.80	0.90
$+6$		0.76	0.59	0.91	0.79	1.01	1.30
12		0.75	0.75	0.95	0.82	0.97	1.41
18		0.61	1.04	1.15	0.70	0.94	1.11
24		0.40	1.23	1.45	0.49	0.84	1.37
28		0.10	1.55	1.55	0.015	0.50	1.47

Table AVII

$C_{n_{\delta_{SP}}}$						
δ_{F_3}	35°			60°		
$\begin{array}{c} C_j \\ \infty \end{array}$	0.	1.94	3.50	0.	1.94	3.50
-10°	.0005	.0006	.0006	.0003	0.	.0003
-2	.0006	.0007	.0008	.0003	0.	.0003
+6	.0006	.0008	.0009	.0003	.0001	.0003
12	.0006	.0008	.0005	.0002	.0002	.0002
18	.0006	.0007	.0008	.0001	.0003	.0003
24	.0005	.0003	.0006	0.	.0008	.0004
28	.0005	0.	.0003	0.	0.	.0010

Table AVIII

$C_{n\delta A}$						
δ_{F_3}	35°			60°		
$\alpha \backslash C_j$	0.	1.59	3.18	0.	1.59	3.18
-10°	0.	.0001	.0001	0.	.0005	.0002
-2	-.0001	-.0001	0.	0.	-.0001	-.0002
+6	-.0003	-.0002	0.	-.0002	-.0002	-.0001
12	-.0003	-.0001	0.	-.0002	-.0001	0.
18	-.0005	-.0001	0.	-.0002	0.	0.
24	-.0004	-.0001	0.	-.0002	-.0001	-.0001
28	-.0005	-.0001	0.	-.0003	0.	-.0002

Table AIX

		$C_{1\delta_{SP}}$					
δ_{F_j}		35°			60°		
∞ \diagdown C_j		0.	1.94	3.50	0.	1.94	3.50
-10°		-.0011	+.0015	.0017	.0006	.0013	.0012
-2		-.0018	+.0020	.0020	.0009	.0016	.0013
+6		-.0021	+.0023	.0023	.0010	.0020	.0017
12		-.0018	+.0019	.0019	.0008	.0025	.0020
18		-.0013	+.0014	.0015	.0003	.0032	.0027
24		-.0007	+.0008	.0012	-.0001	+.0038	.0037
28		-.0004	+.0005	.0006	-.0002	+.0008	.0052

Table AX

$C_{1\delta_A}$						
δ_{F_3}	35°			60°		
$\alpha \backslash C_j$	0.	1.59	3.18	0.	1.59	3.18
-10°	-.0002	+.0017	.0029	.0008	.0011	.0023
-2	+.0001	.0023	.0033	.0002	.0018	.0025
+6	.0008	.0024	.0034	.0007	.0016	.0027
12	.0005	.0028	.0038	.0003	.0017	.0025
18	.0006	.0010	.0029	.0004	.0018	.0023
24	.0008	.0010	.0008	.0006	.0001	.0005
28	.0002	.0001	-.0002	+.0004	0.	.0006

Table AXI

$C_{L_{GE}} / C_L$						
S_{F_3}	35°			70°		
$\begin{array}{c} C_j \\ h/b \end{array}$	0.	1.89	3.78	0.	1.89	3.78
.1	1.19	1.08	1.04	1.21	.91	.79
.2	1.125	1.05	1.03	1.11	.96	.975
.3	1.06	1.03	1.02	1.05	1.01	1.03
.4	1.01	1.01	1.01	1.025	1.025	1.03
.5	1.005	1.005	1.005	1.010	1.015	1.015
.6	1.0	1.0	1.0	1.0	1.0	1.0

Table AXII

		ΔC_{DGE}					
δ_{F_3}		35°			70°		
h/b	C_j	0.	1.89	3.78	0.	1.89	3.78
.1		-.02	-.05	-.10	-.04	-.35	-.60
.2		-.01	-.03	-.04	-.02	-.21	-.28
.3		0.	-.01	-.01	-.01	-.09	-.13
.4		0.	0.	0.	0.	-.03	-.06
.5		0.	0.	0.	0.	-.01	-.02
.6		0.	0.	0.	0.	0.	0.

Table AXIII

$\Delta C_{m.40_{GE}}$						
δ_{F_3}	35°			70°		
$\begin{matrix} C_j \\ h/b \end{matrix}$	0.	1.89	3.78	0.	1.89	3.78
.1	-.09	-.29	-.39	-.12	-.42	-.38
.2	-.08	-.13	-.18	-.07	-.28	-.36
.3	-.03	-.03	-.06	-.04	-.16	-.22
.4	0.	-.01	-.02	-.02	-.08	-.08
.5	0.	0.	-.01	-.01	-.02	-.01
.6	0.	0.	0.	0.	0.	0.

Table AIV

$C_{L\text{MAX}3E}$		
$C_j \backslash \delta_{F_3}$	35°	60°
0.	2.4	2.2
0.97	4.03	4.35
1.93	4.92	5.58
2.90	5.87	7.05
3.85	6.29	8.15

Table AXV

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

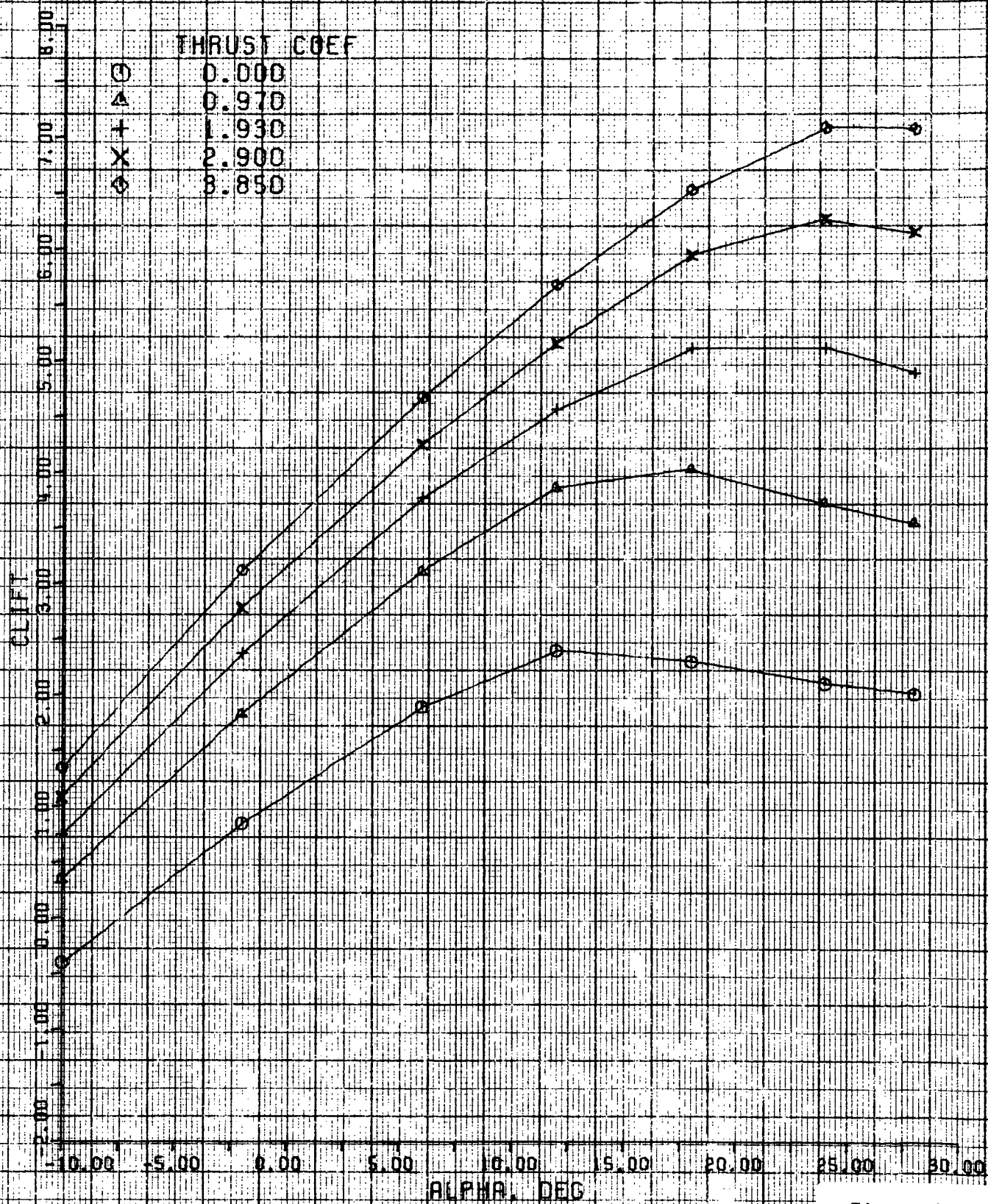


Figure A1

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

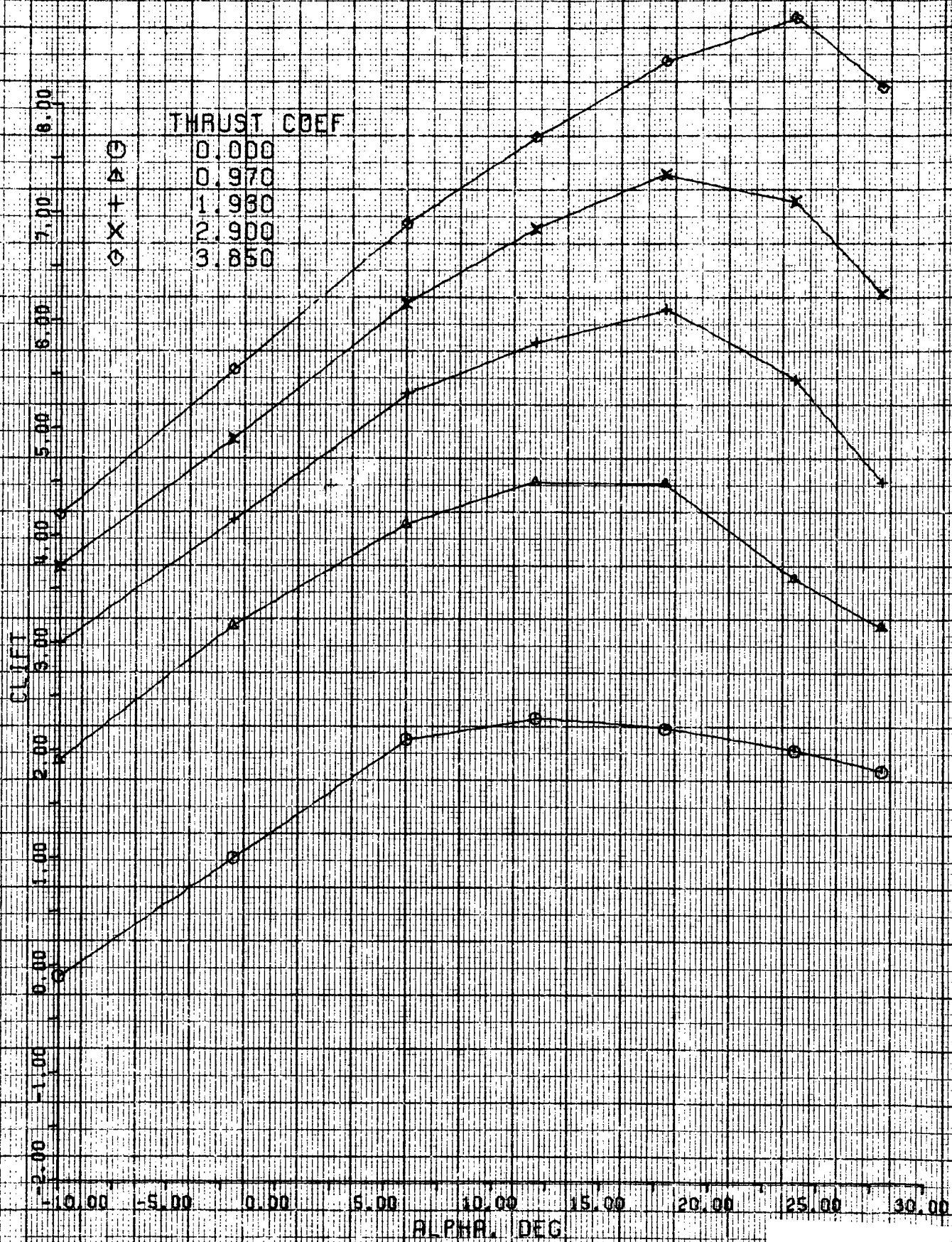


Figure A2

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

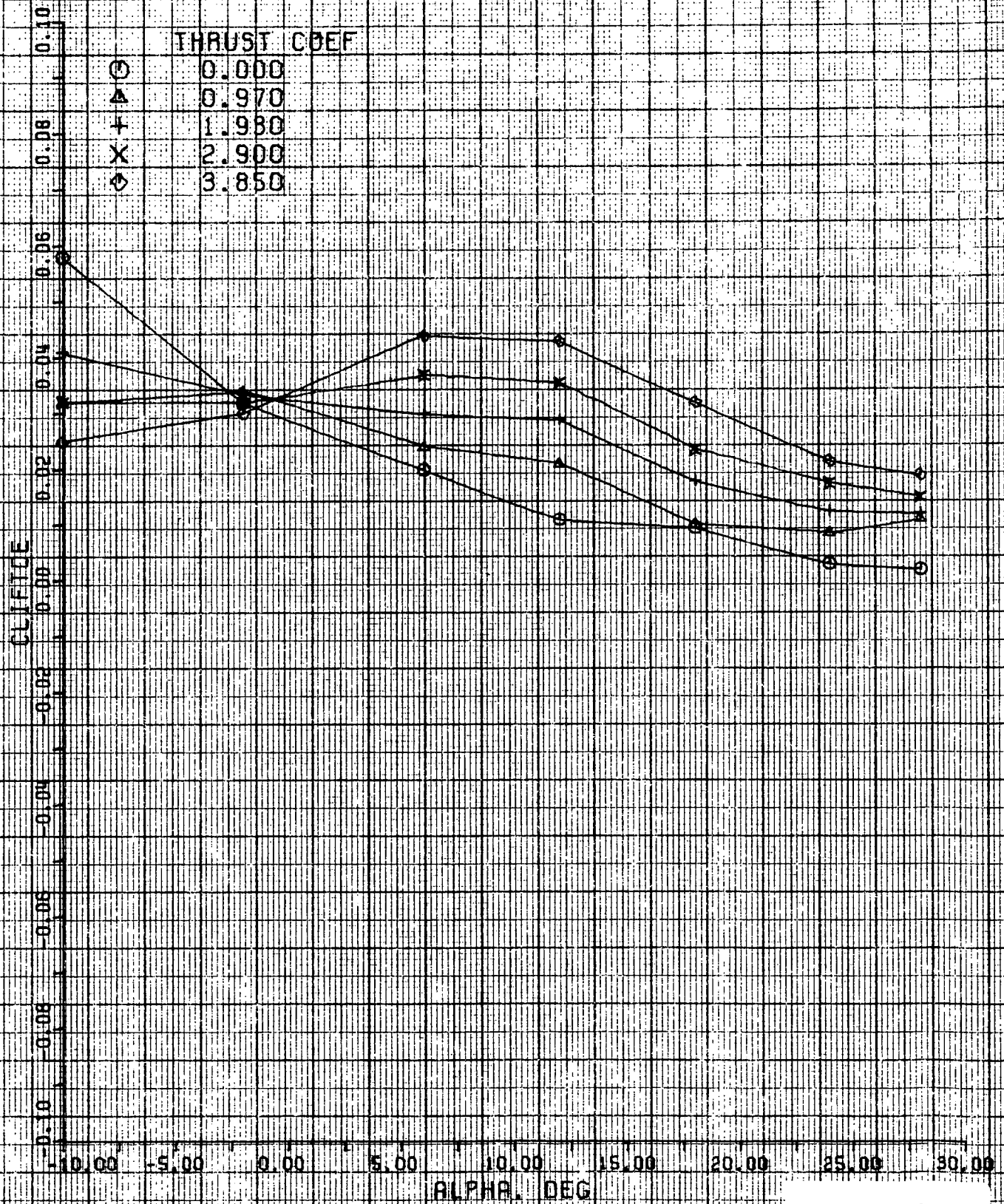


Figure A3

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

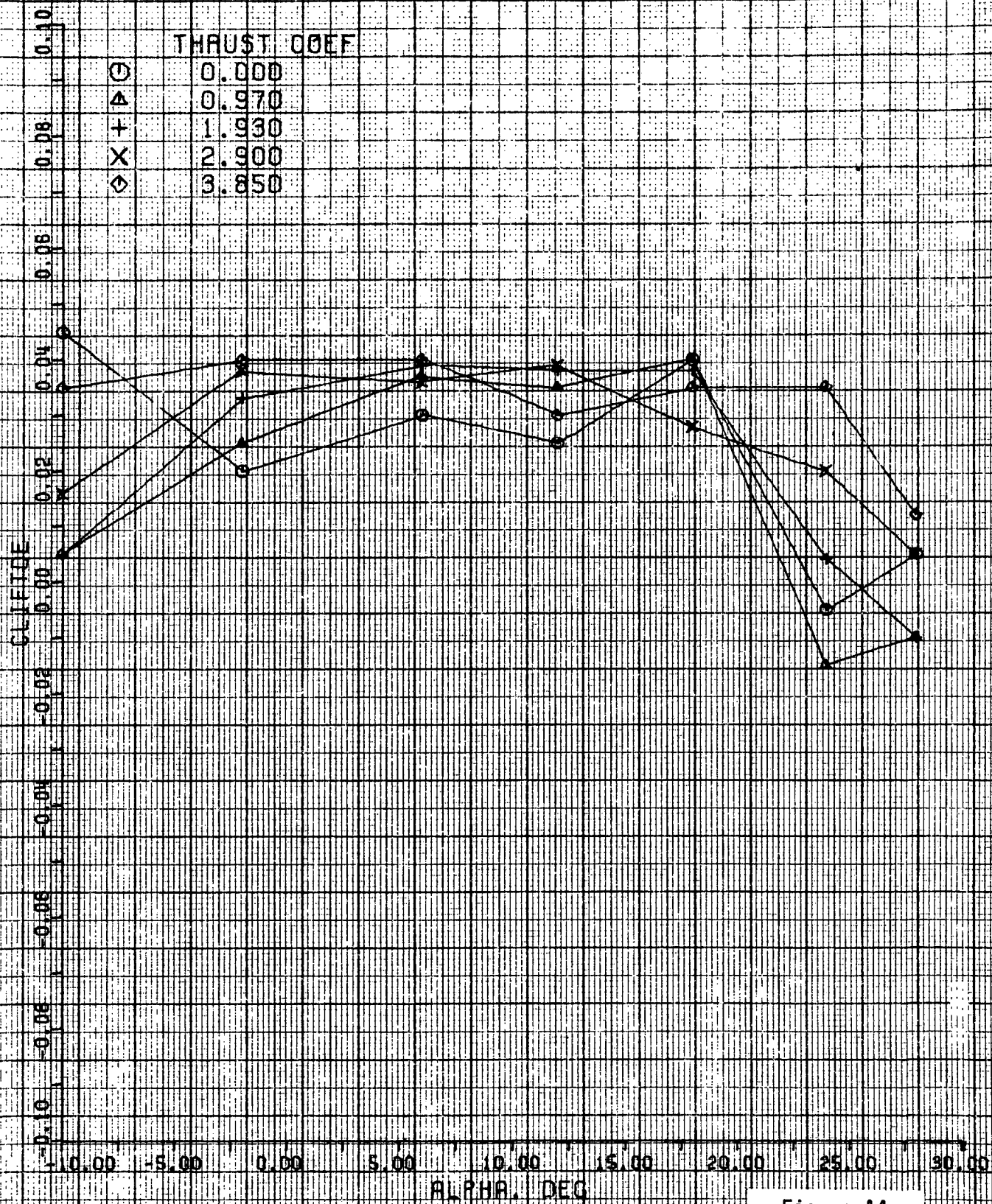


Figure A4

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

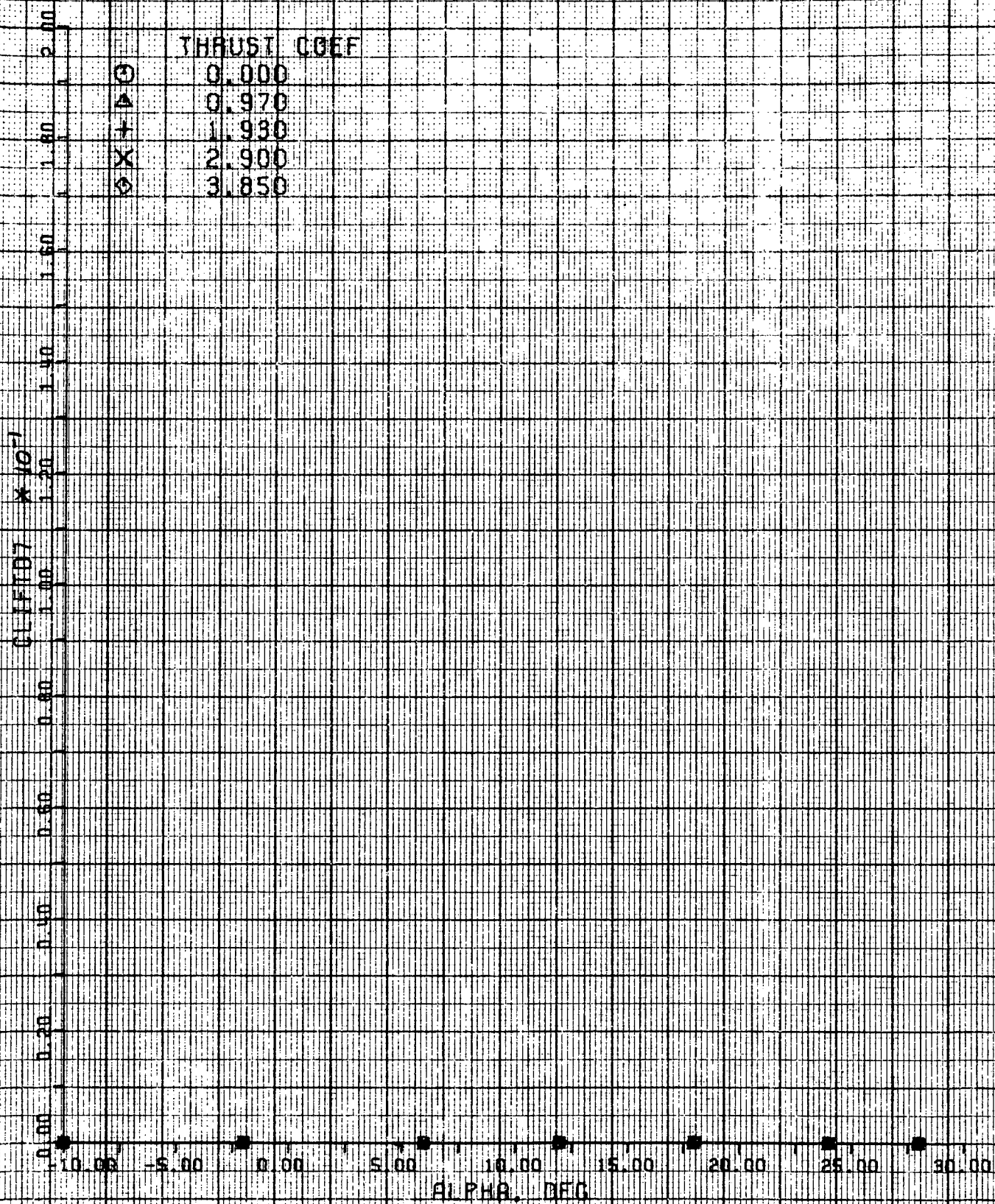


Figure A5

BBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

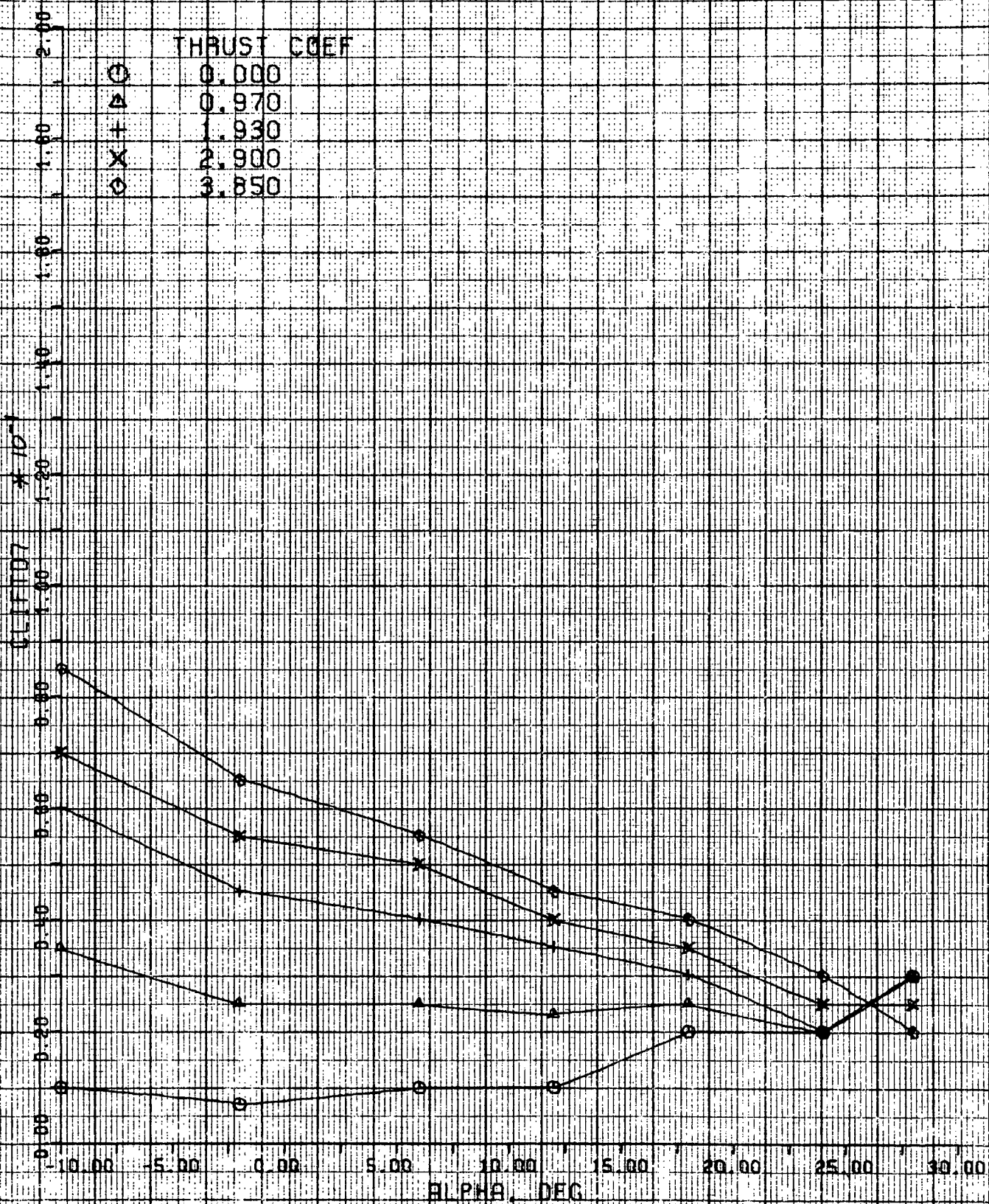


Figure A6

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

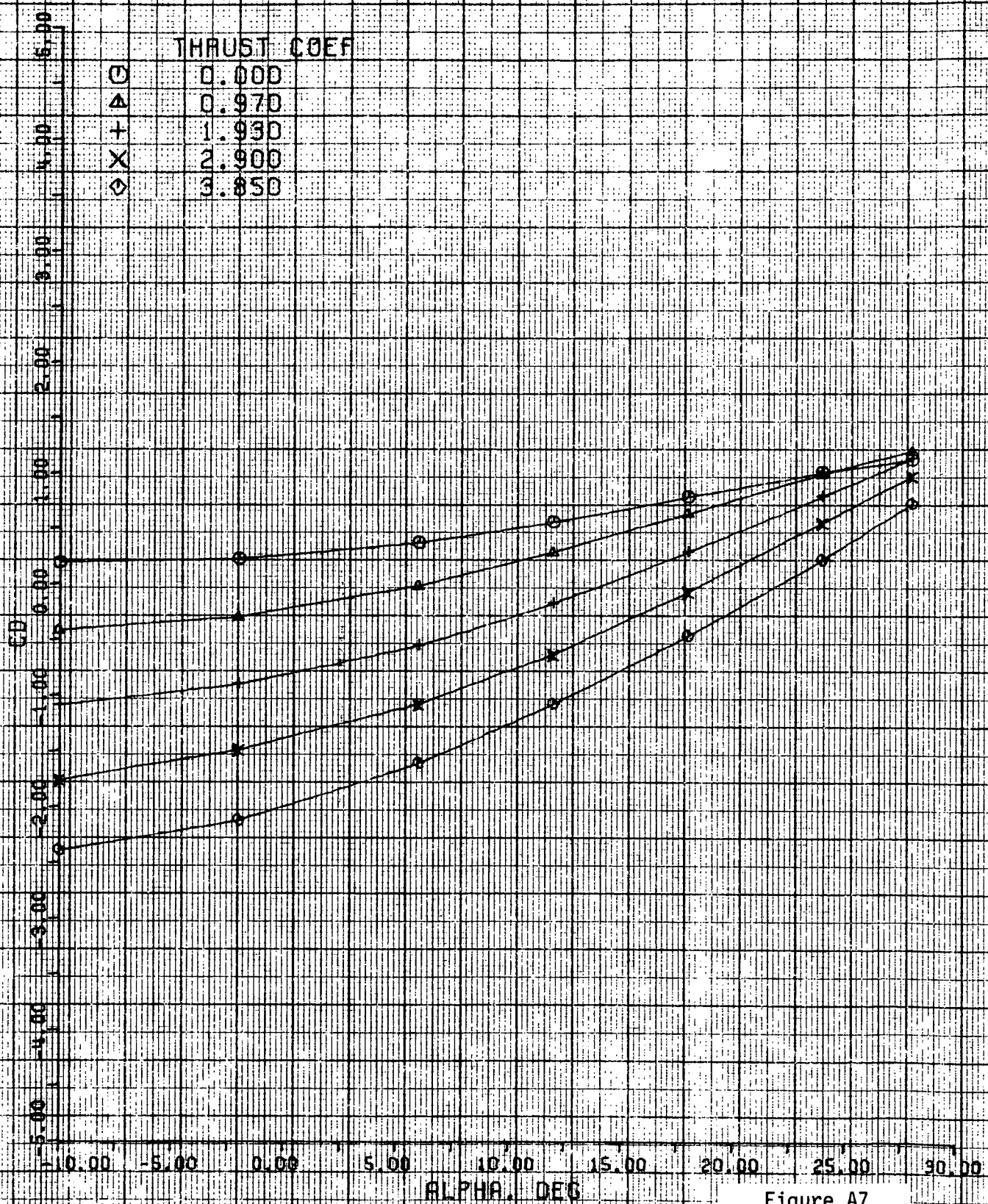


Figure A7

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

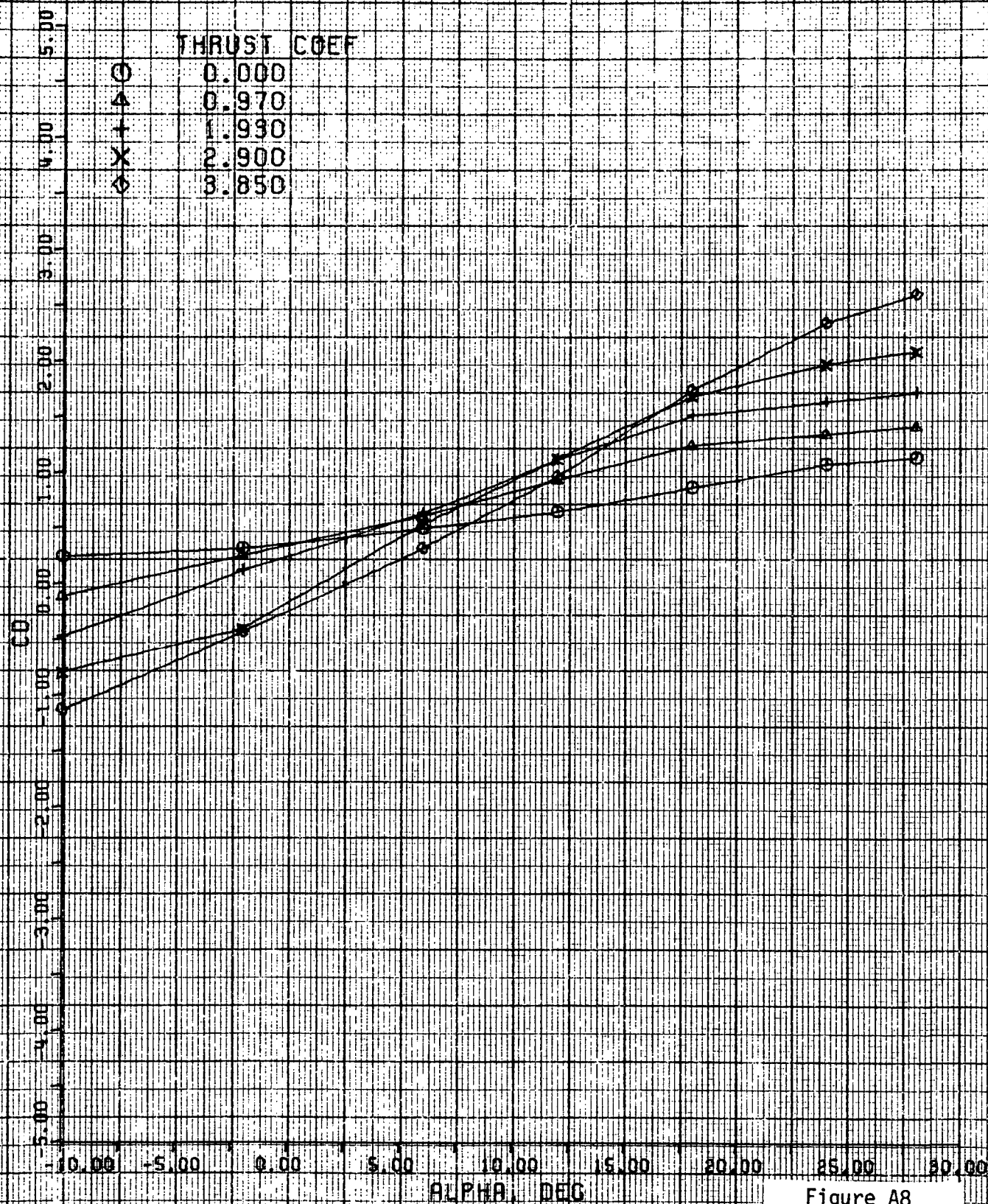


Figure A8

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

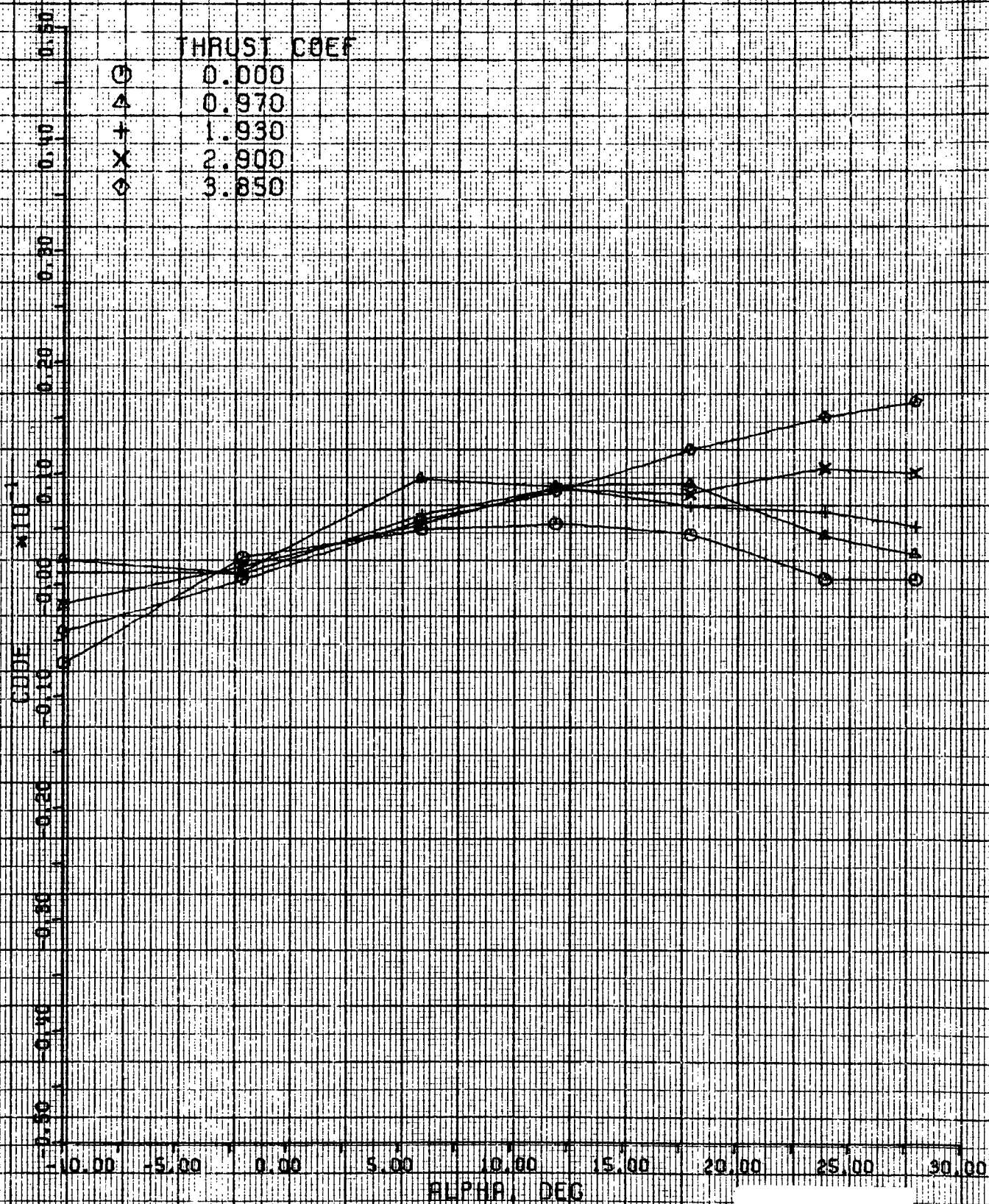


Figure A9

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

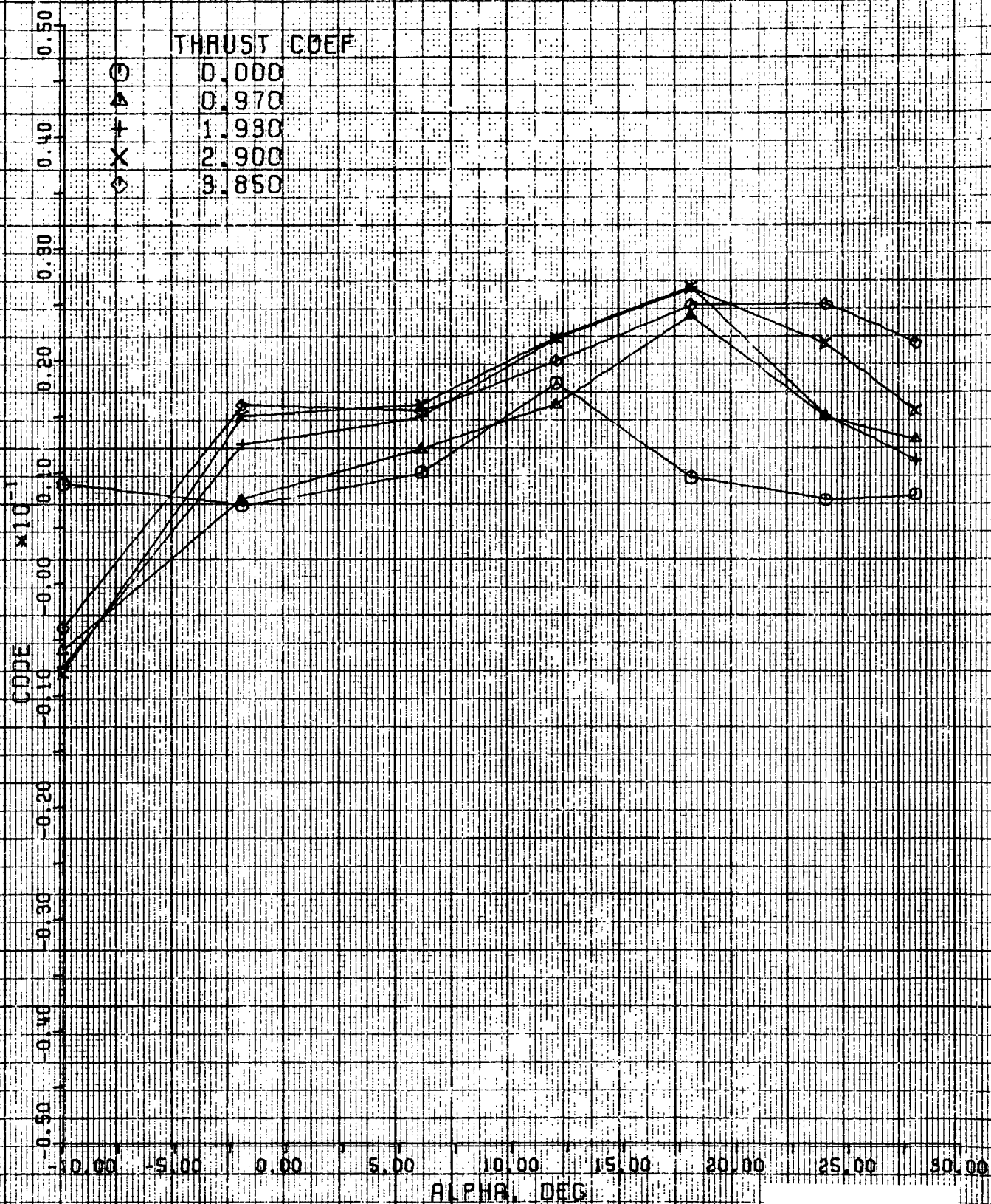


Figure A10

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

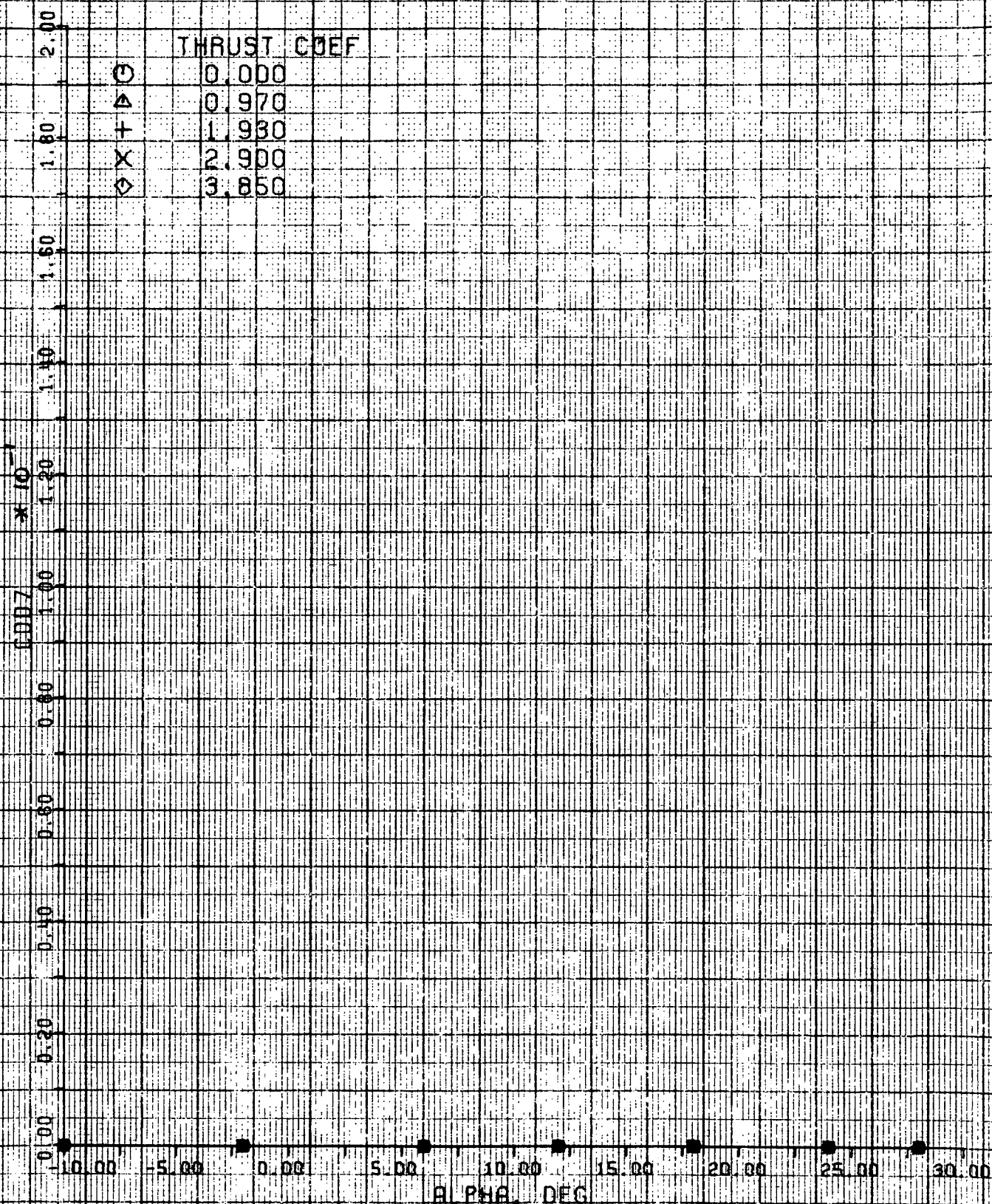


Figure A11

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

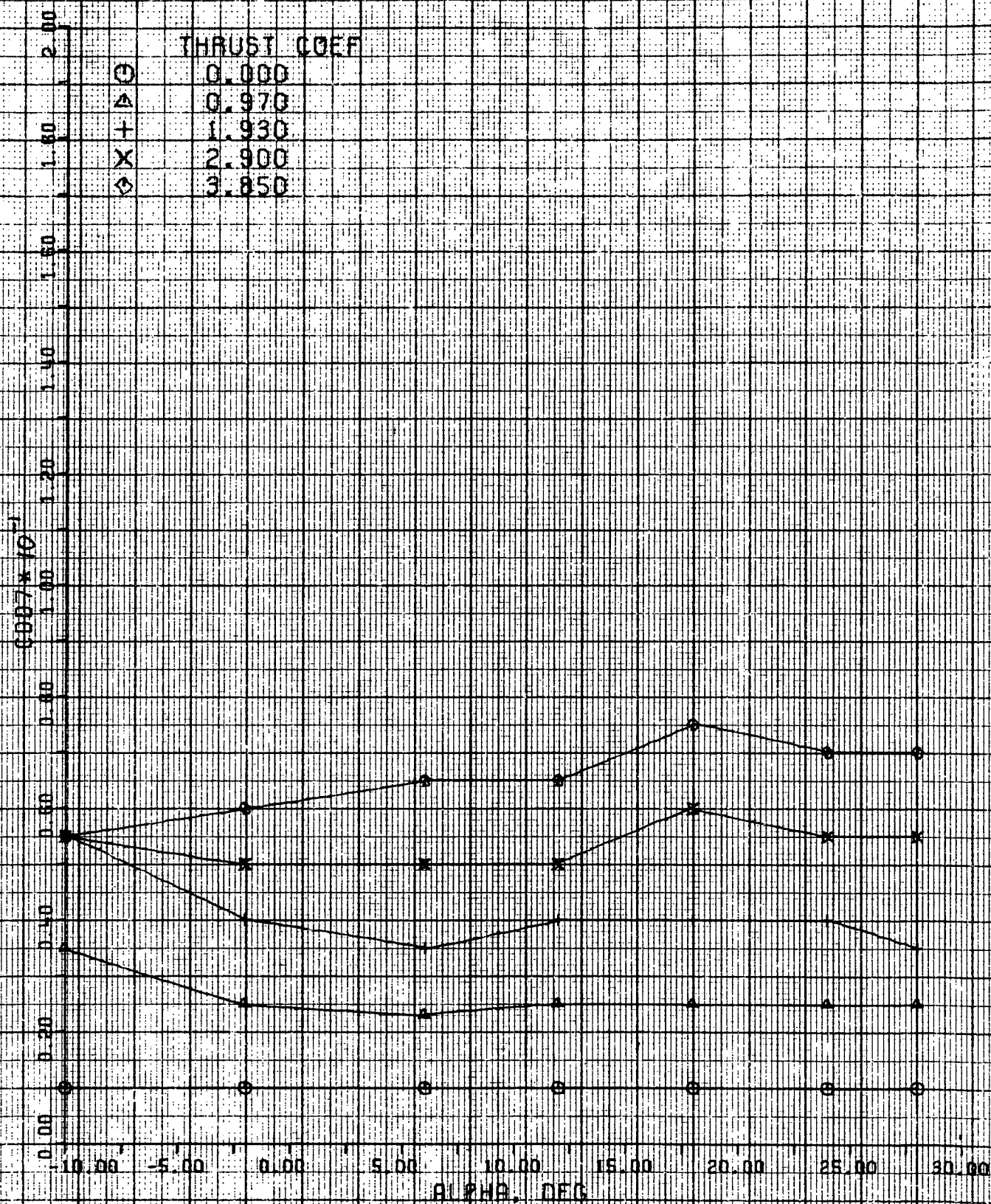


Figure A12

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

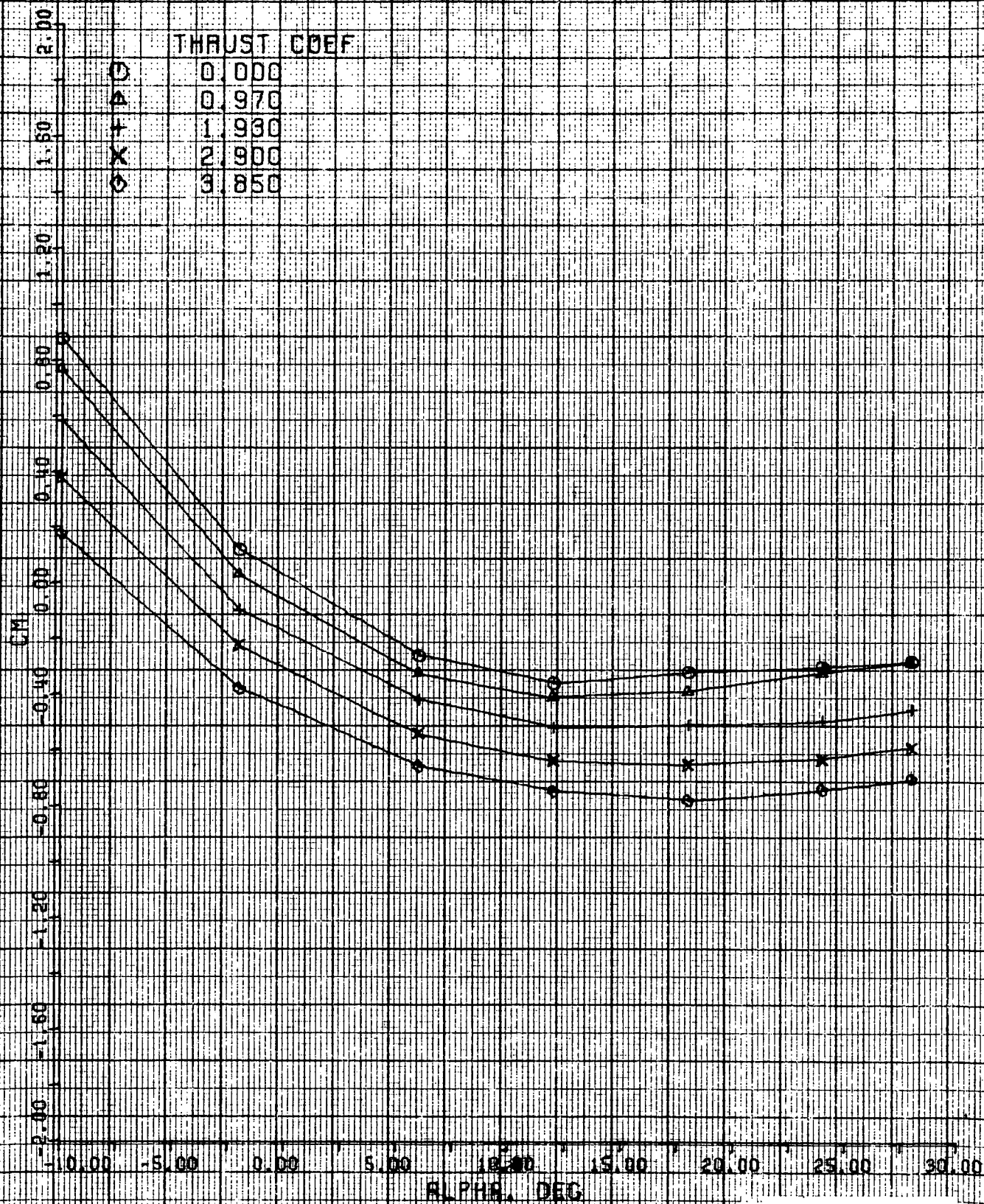


Figure A13

EBF STOL SPREAD ENGINE 4-4-72
80 DEG FLAP SETTING

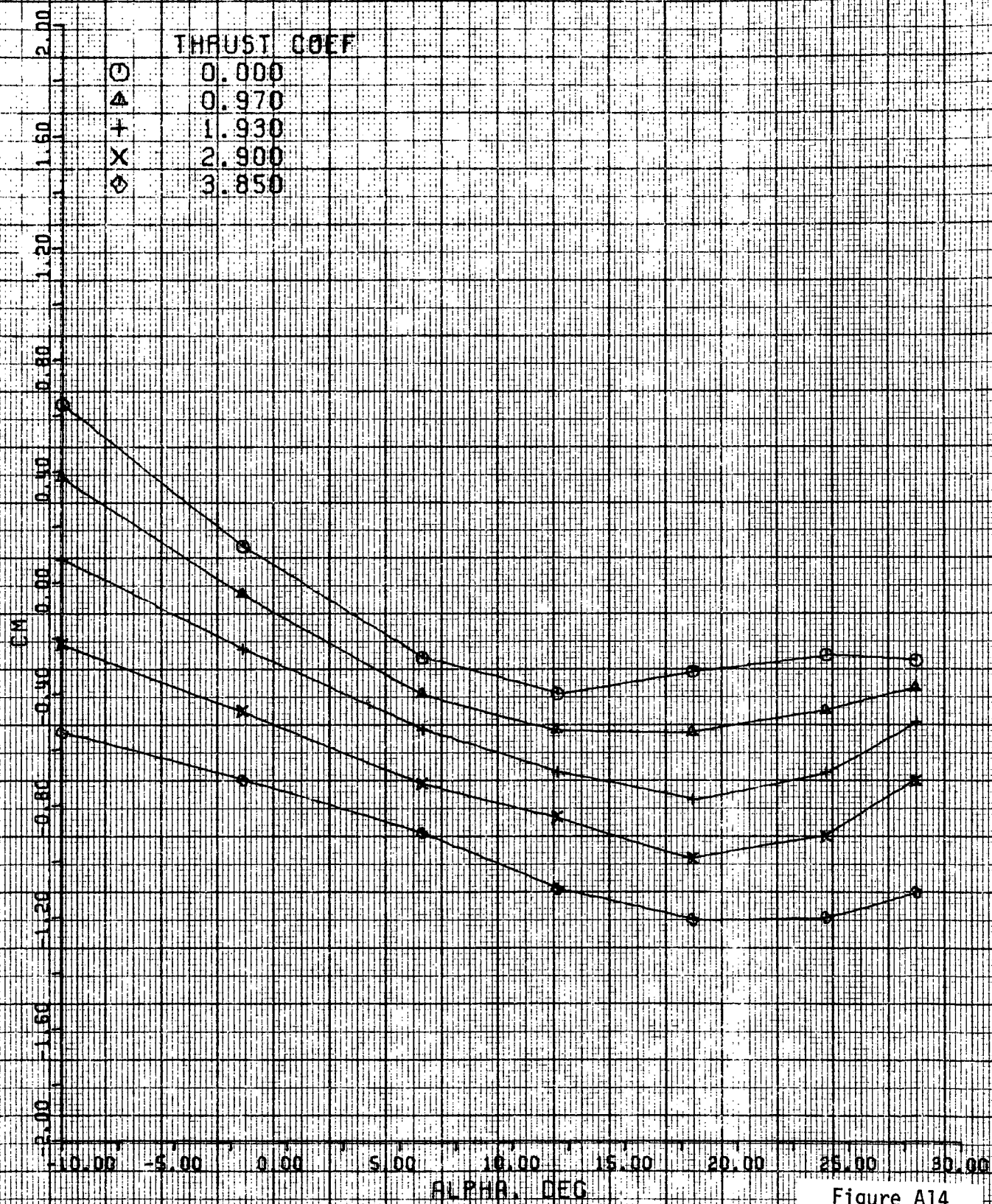


Figure A14

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

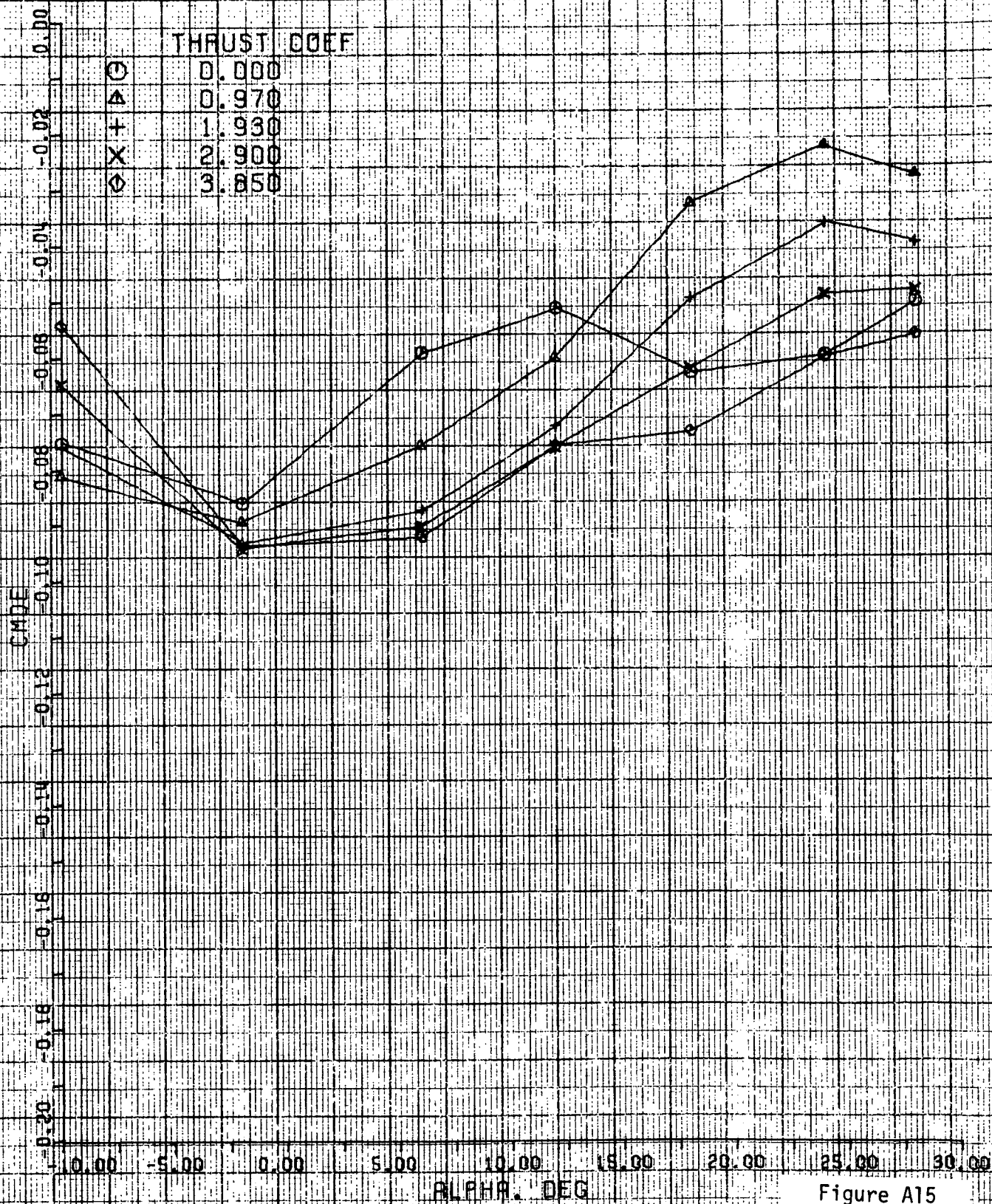


Figure A15

EBF STOL SPREAD ENGINE 4-4-72
80 DEG FLAP SETTING

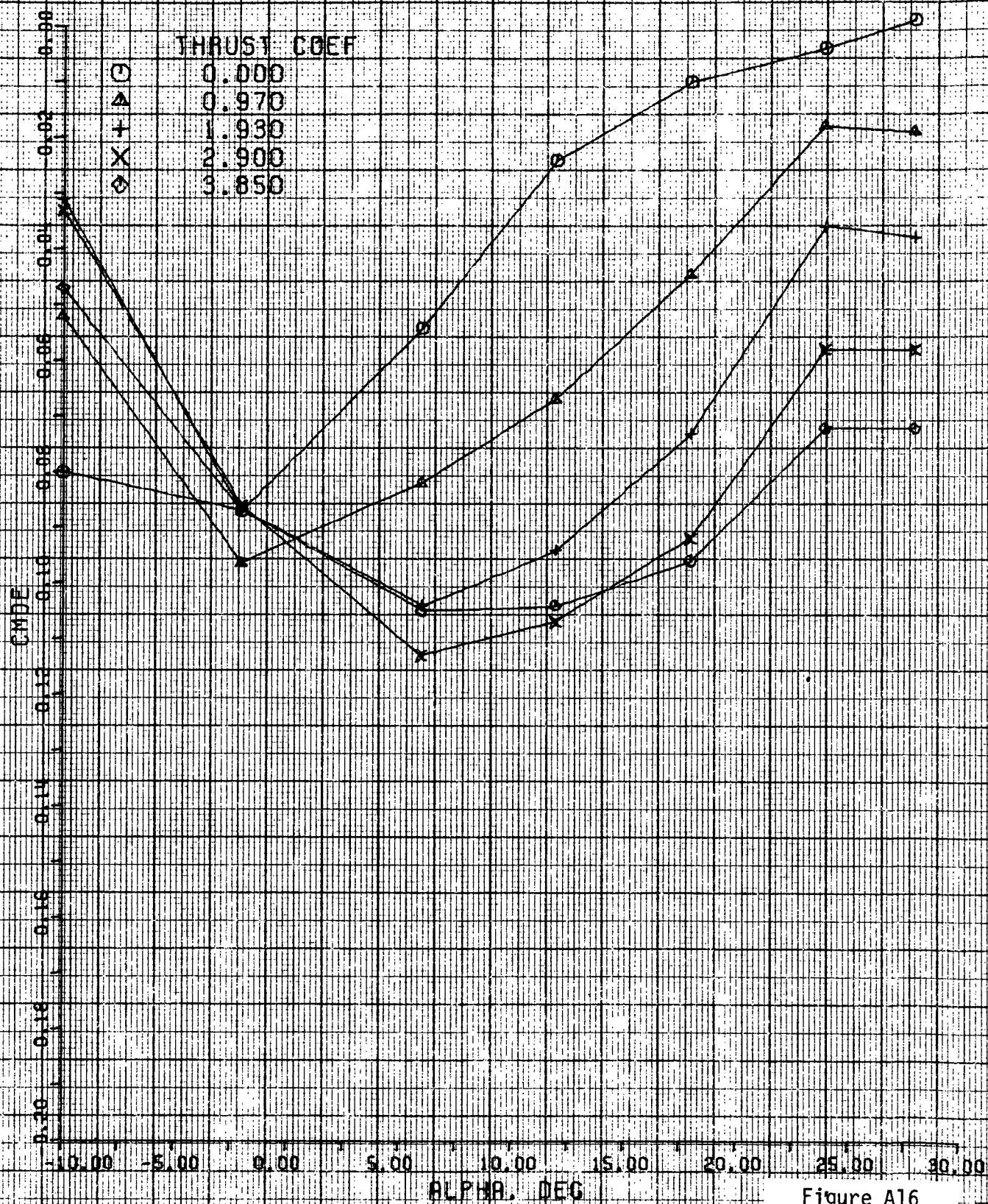


Figure A16

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

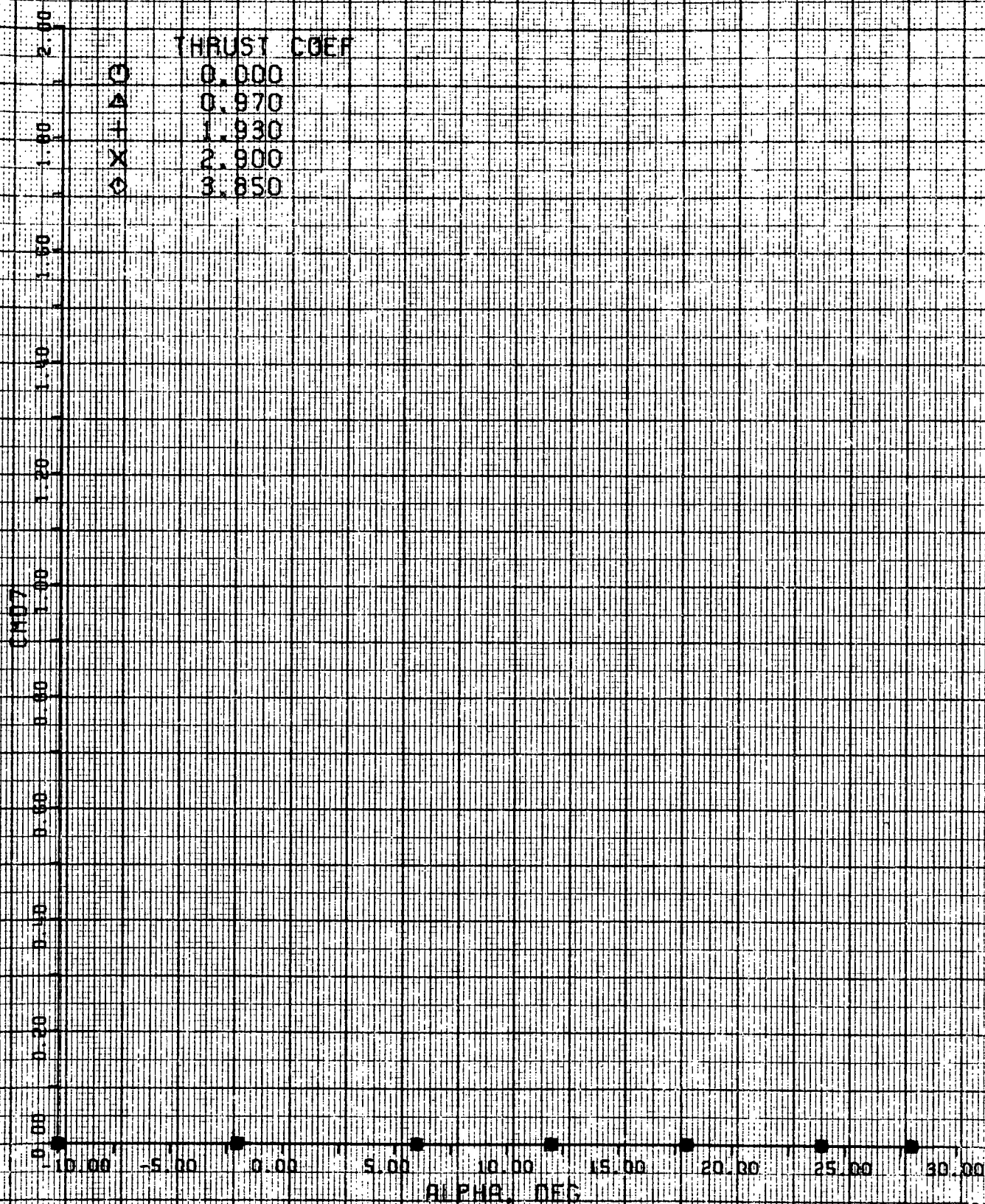


Figure A17

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

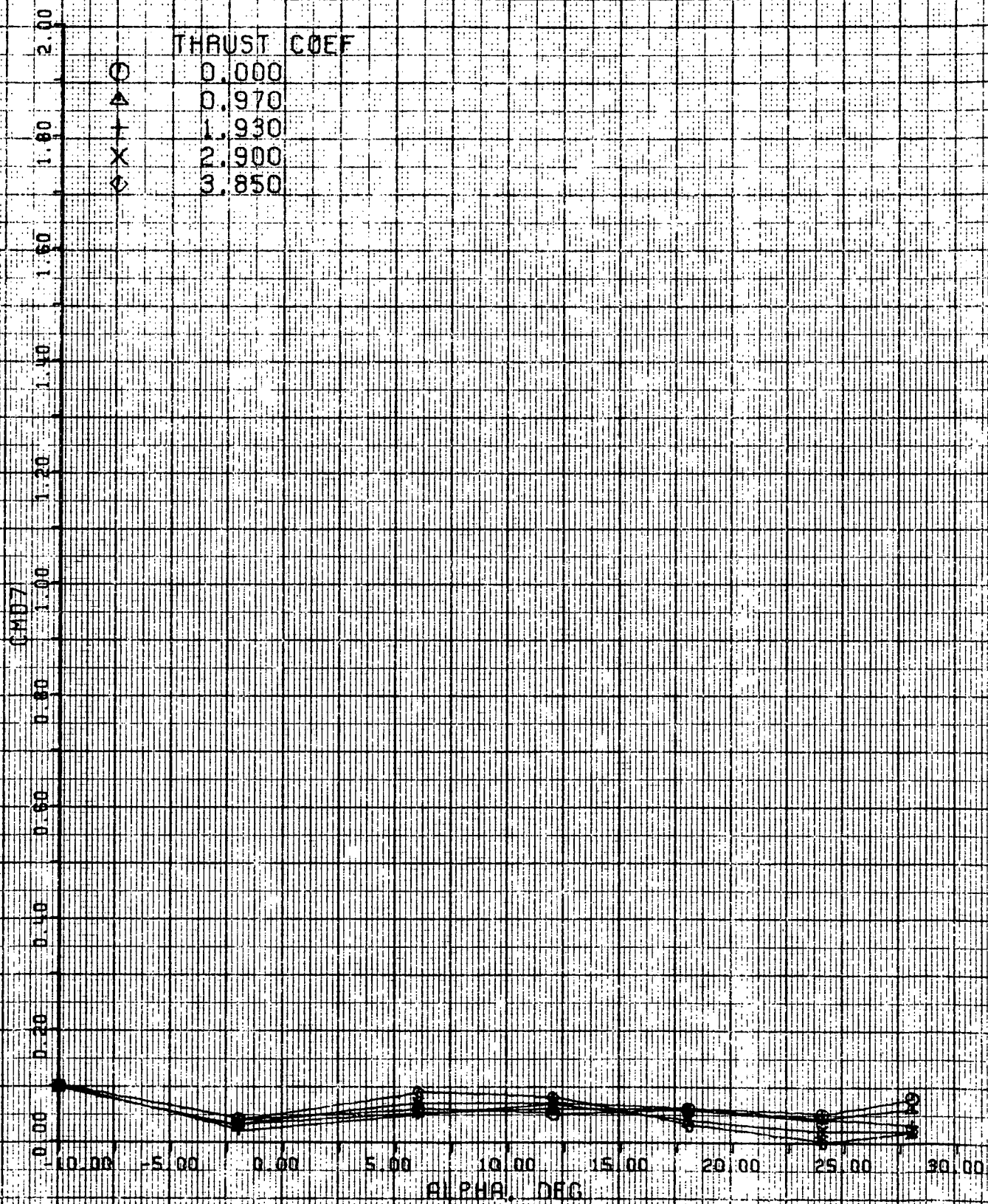


Figure A18

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

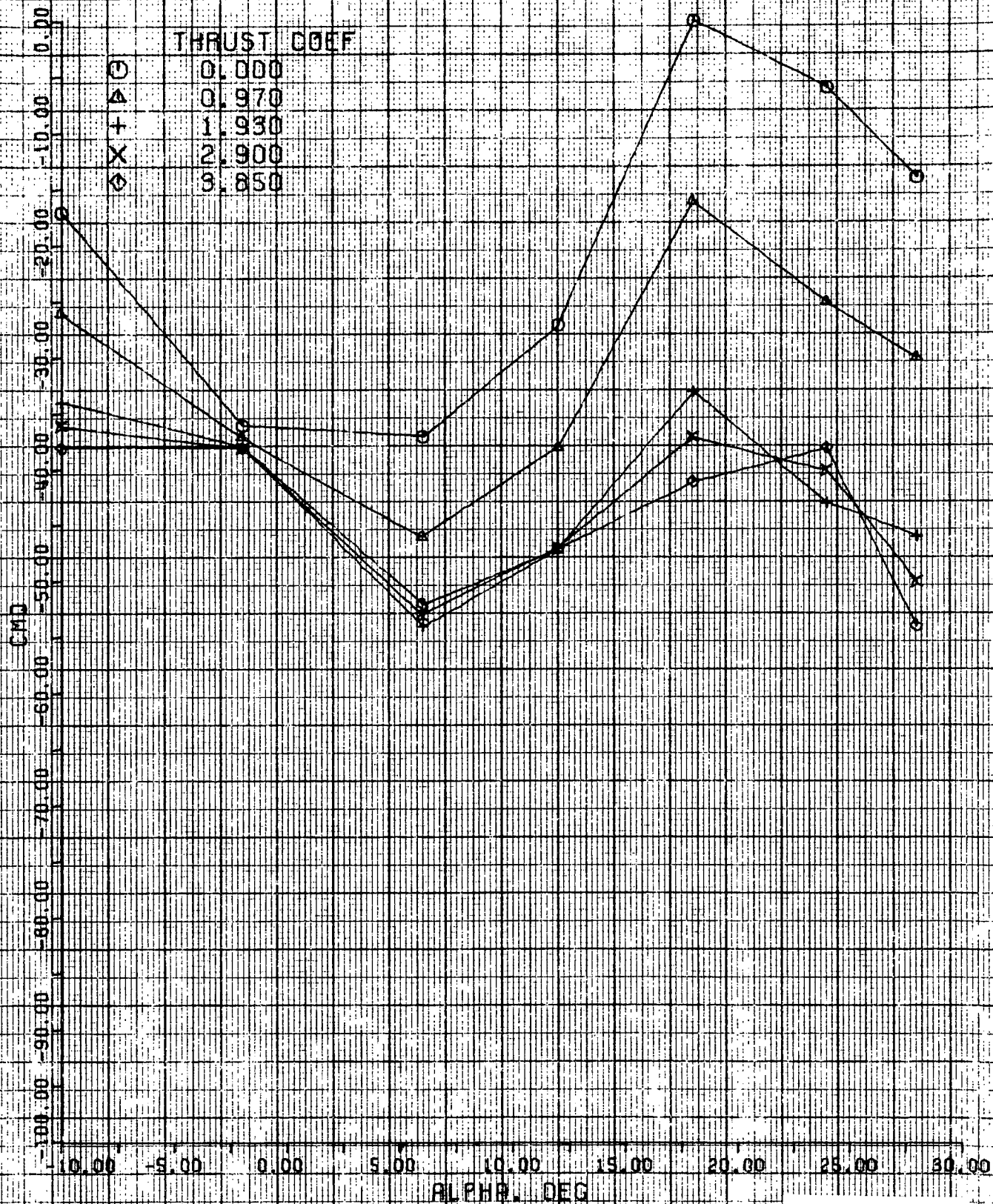


Figure A19

EBF STOL SPREAD ENGINE 4-4-72
 50 DEG FLAP SETTING

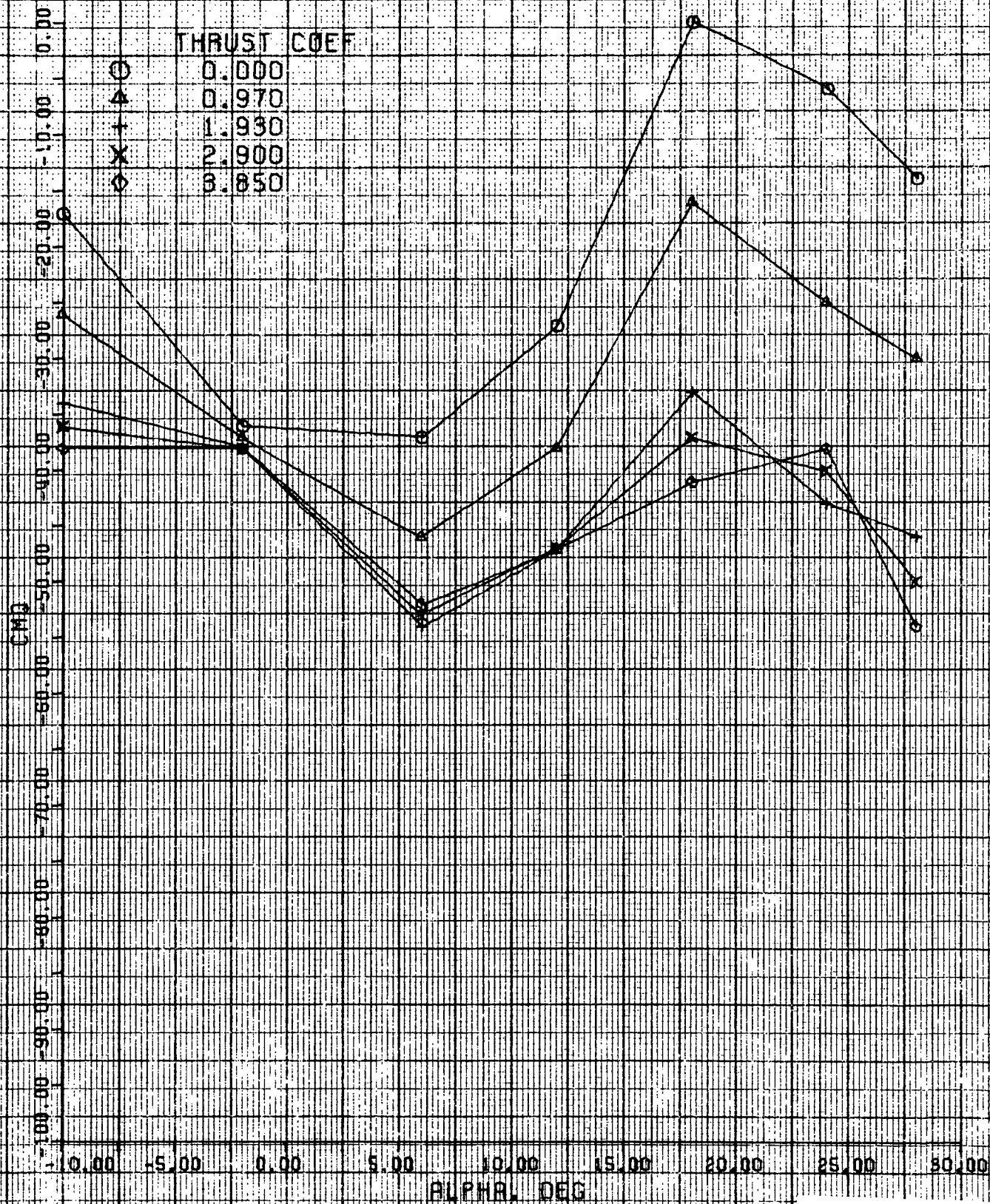


Figure A20

CBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

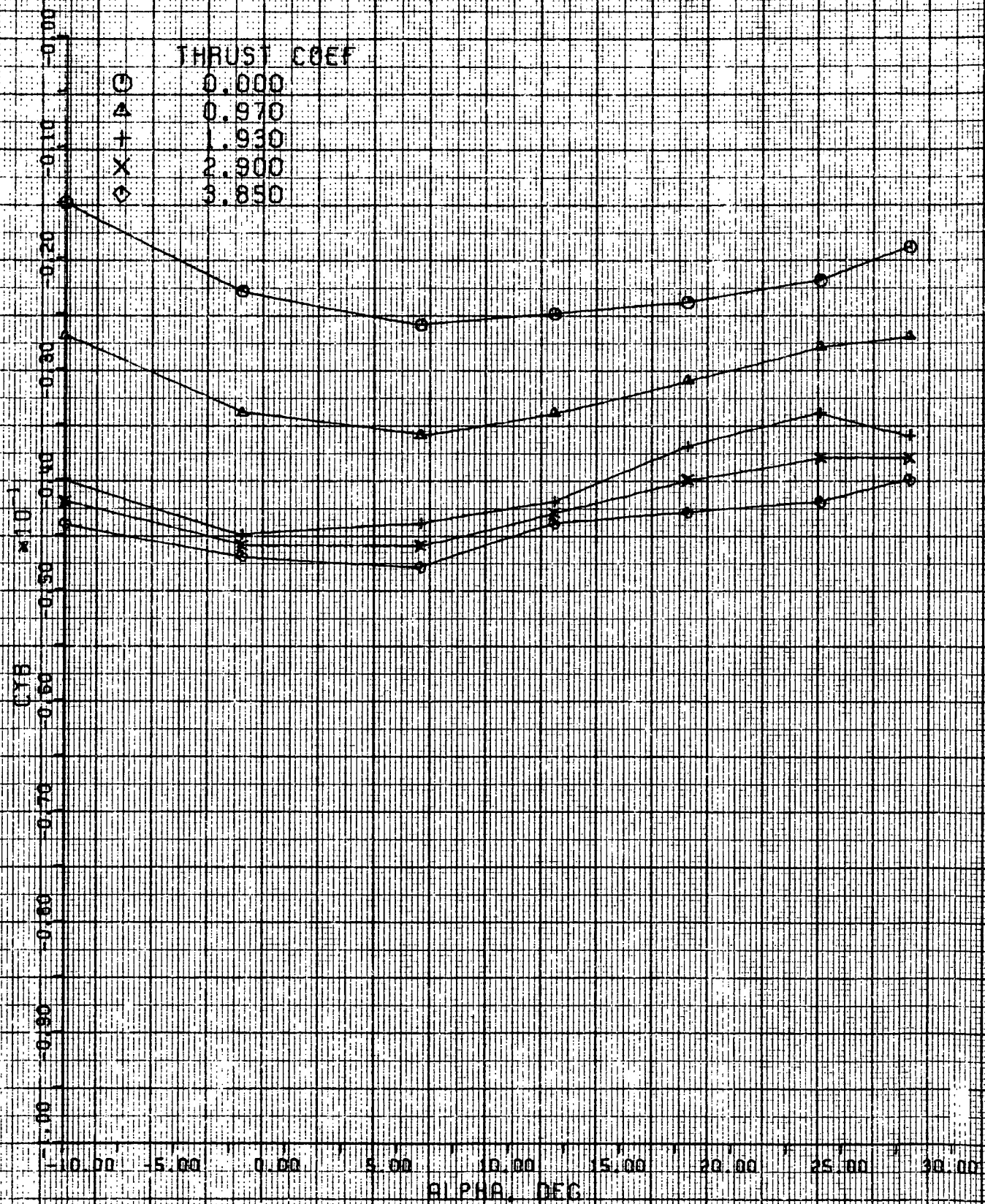


Figure A21

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

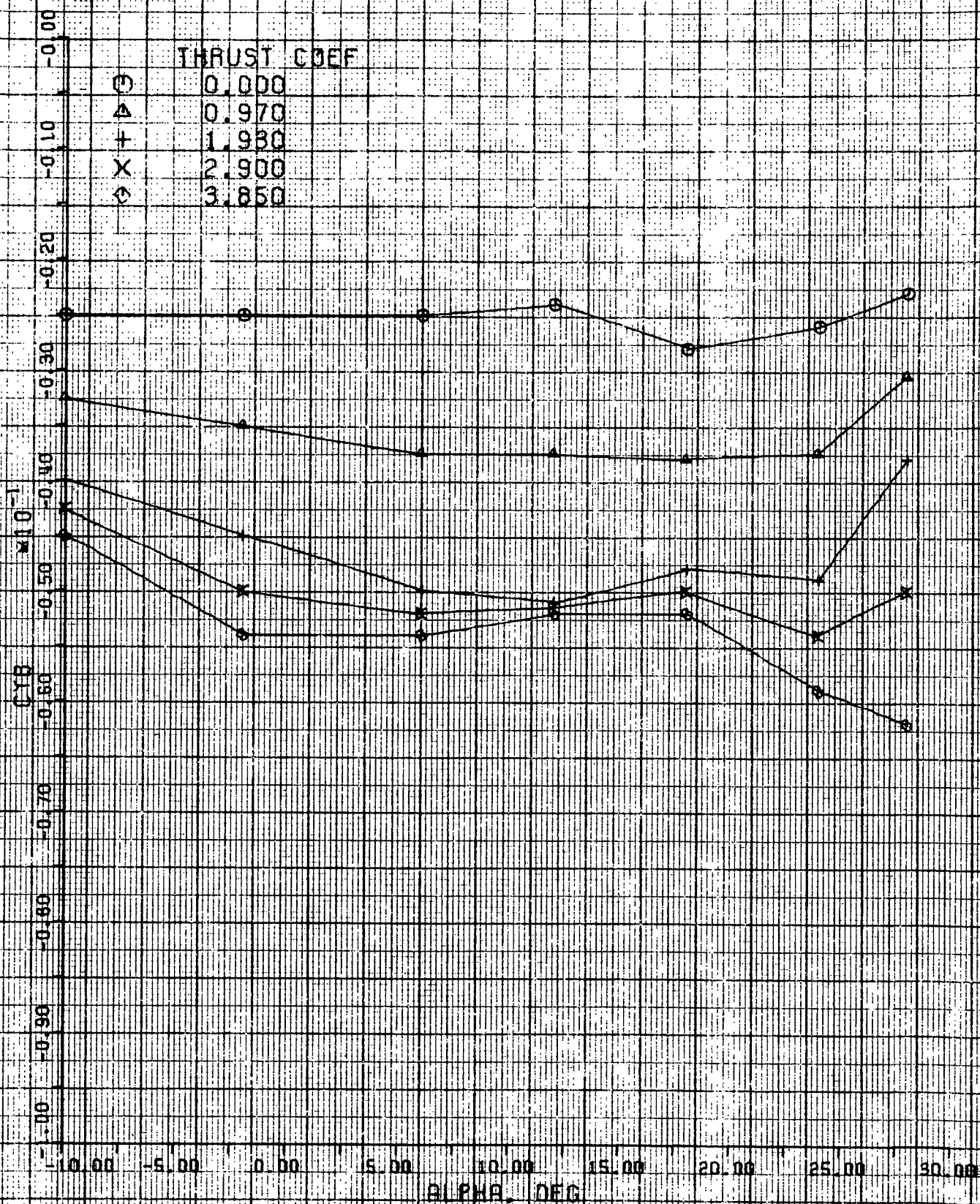


Figure A22

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

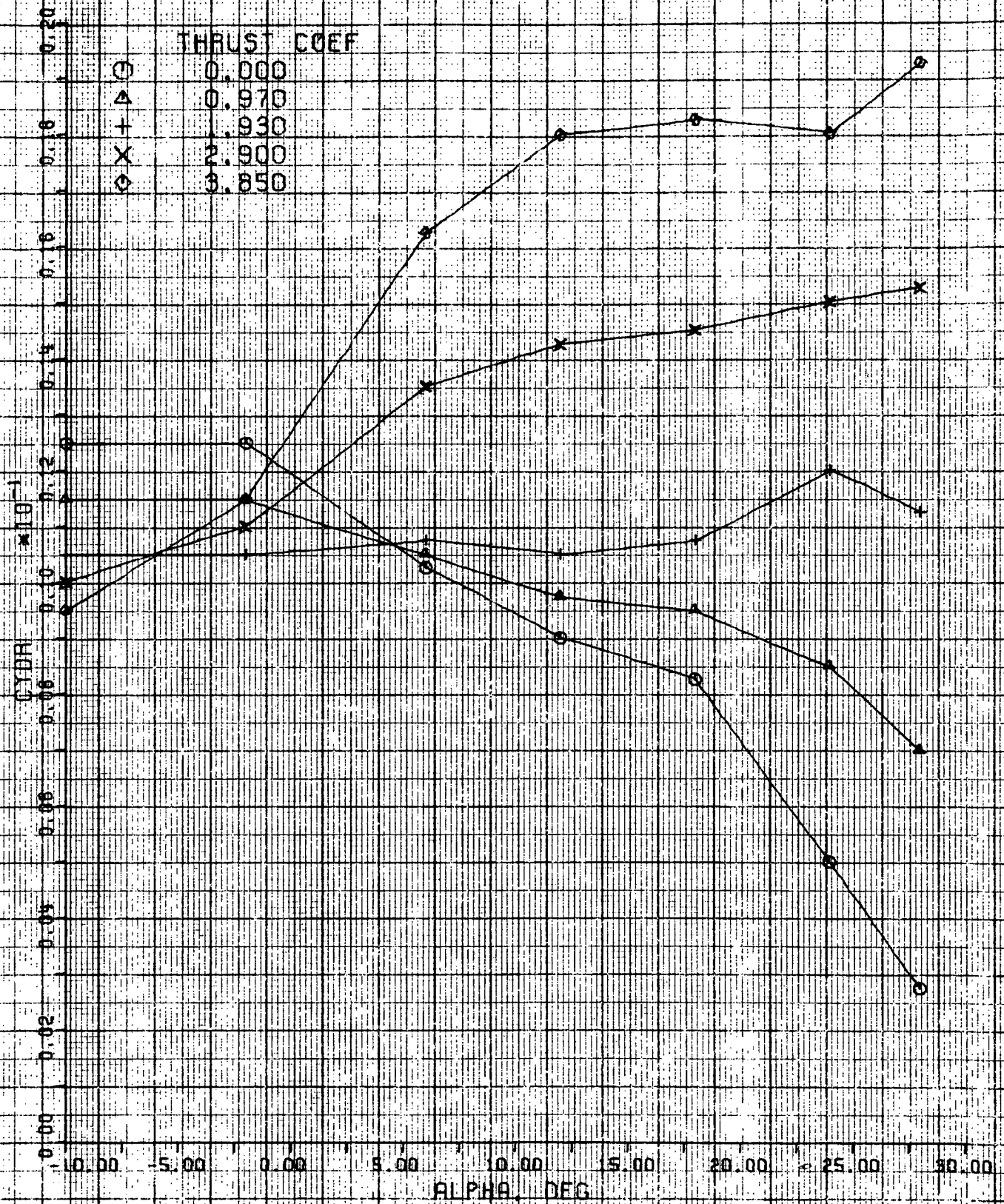


Figure A23

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

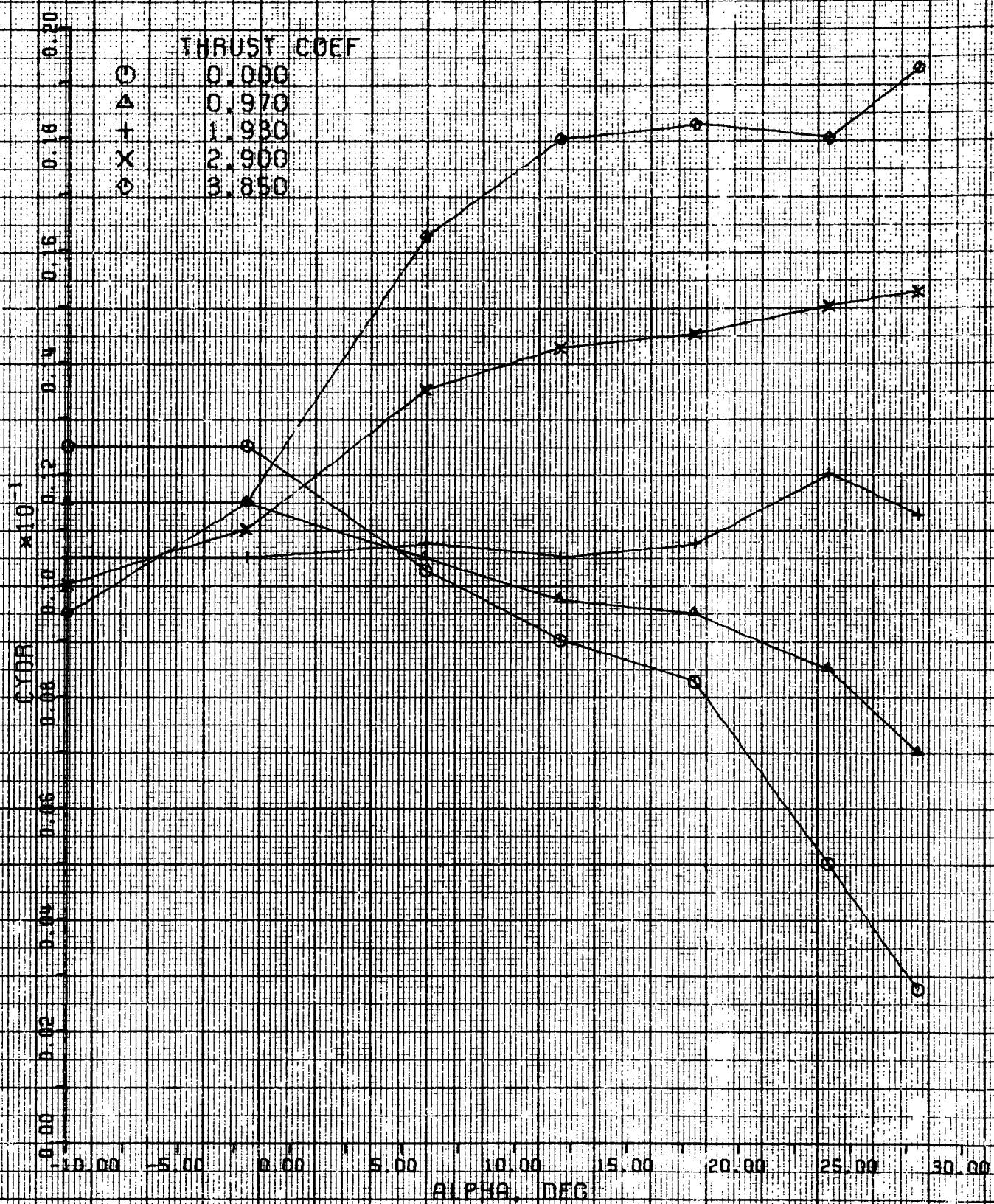


Figure A24

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

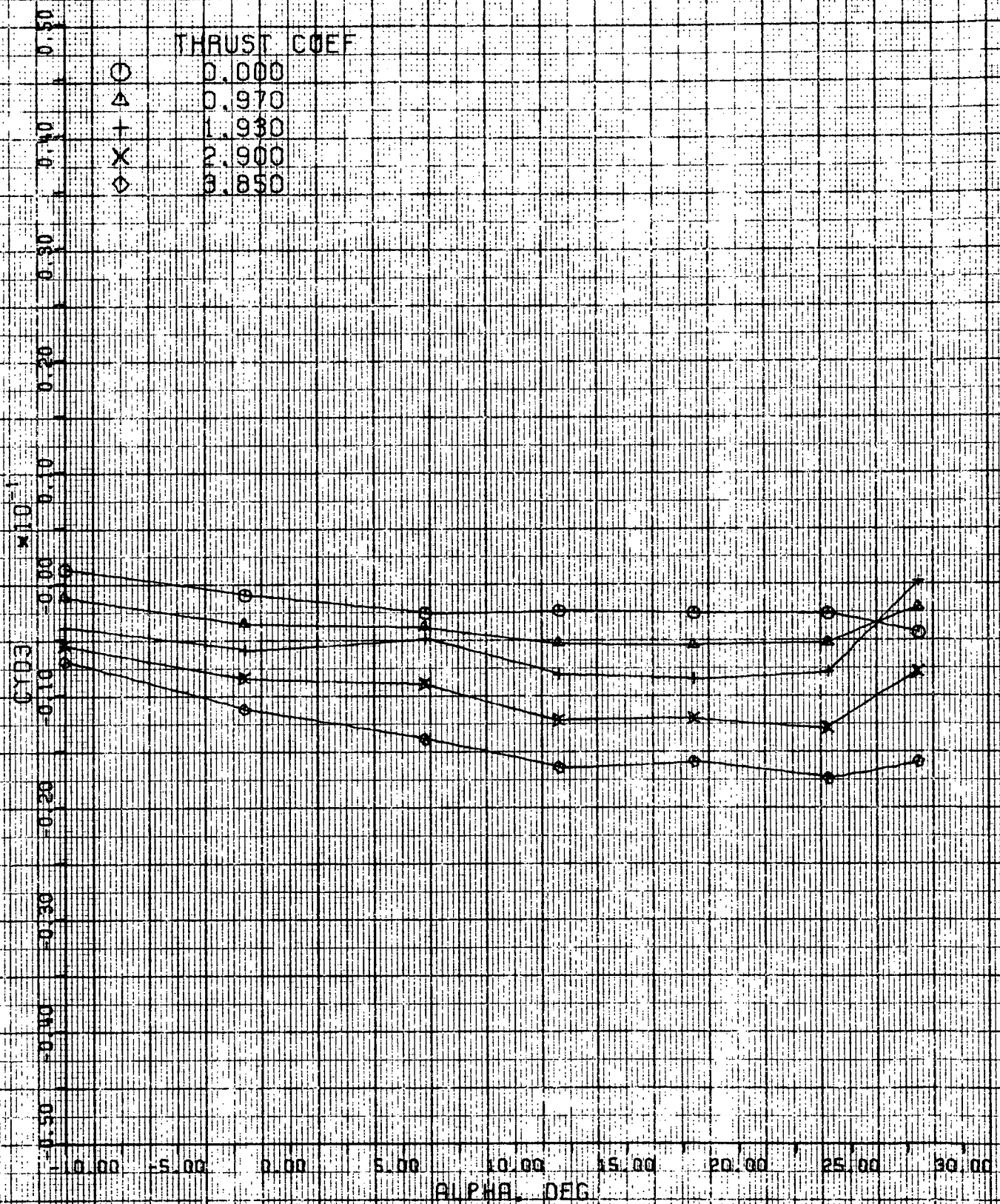


Figure A25

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

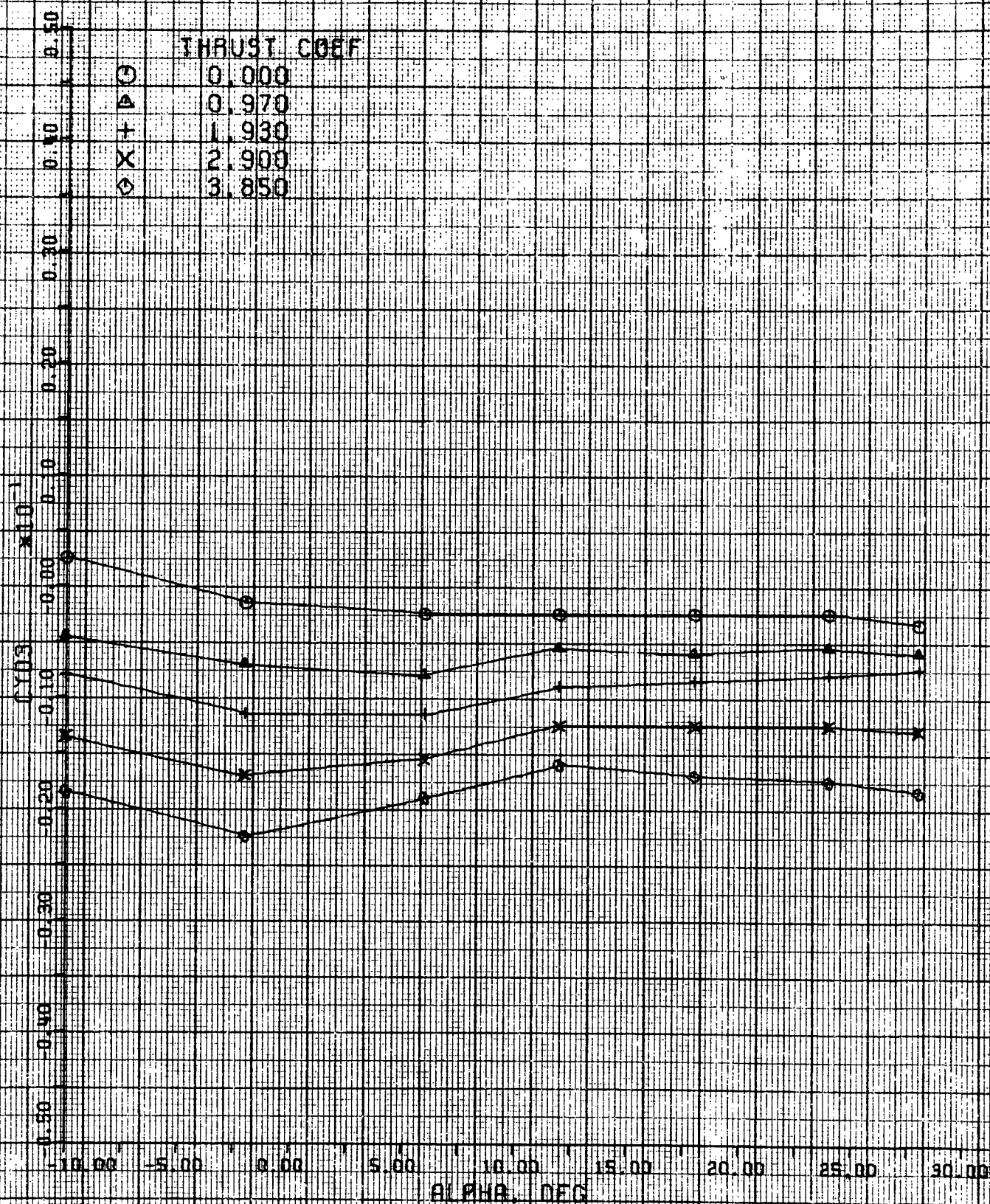


Figure A26

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

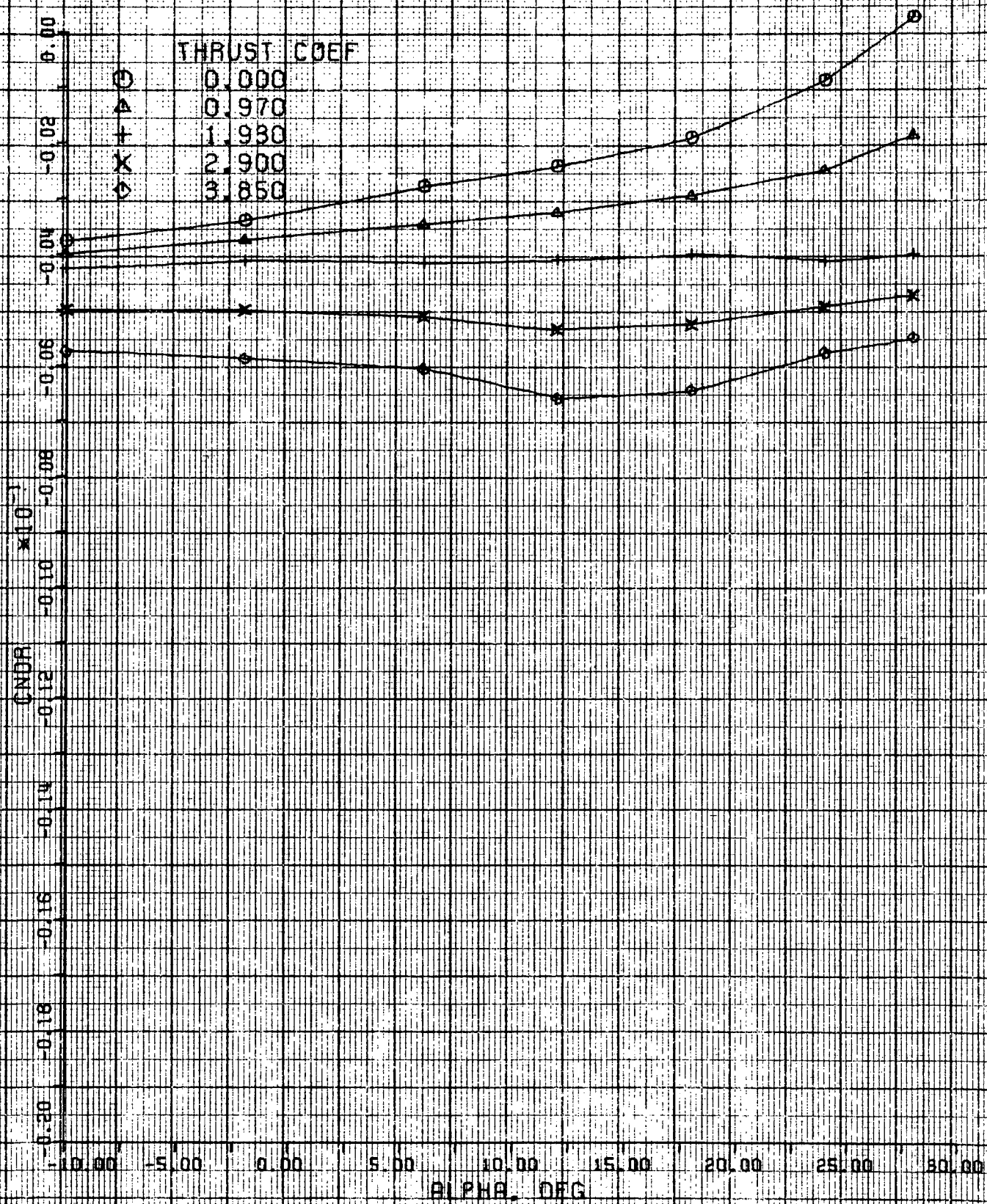


Figure A27

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

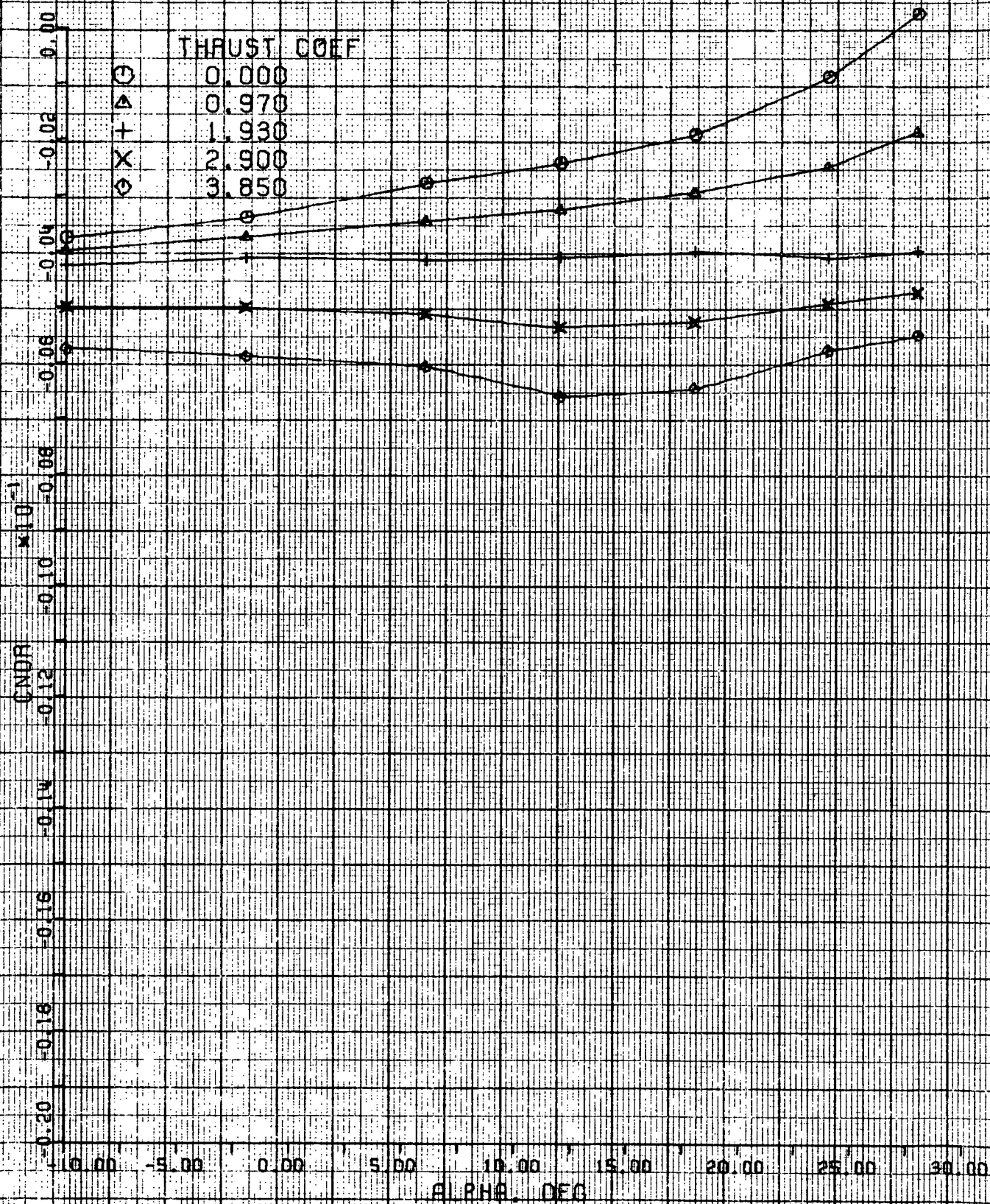


Figure A28

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

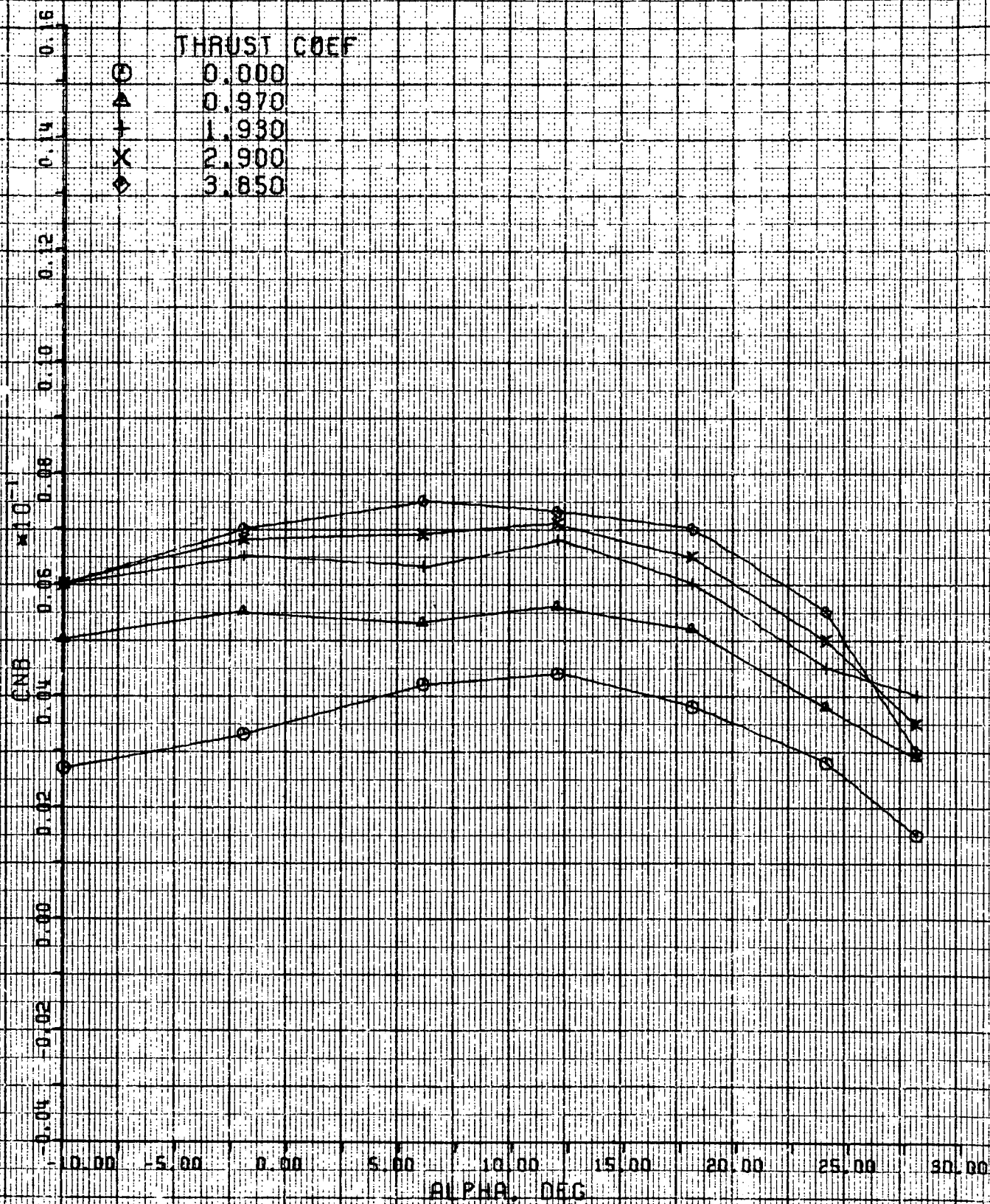


Figure A29

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

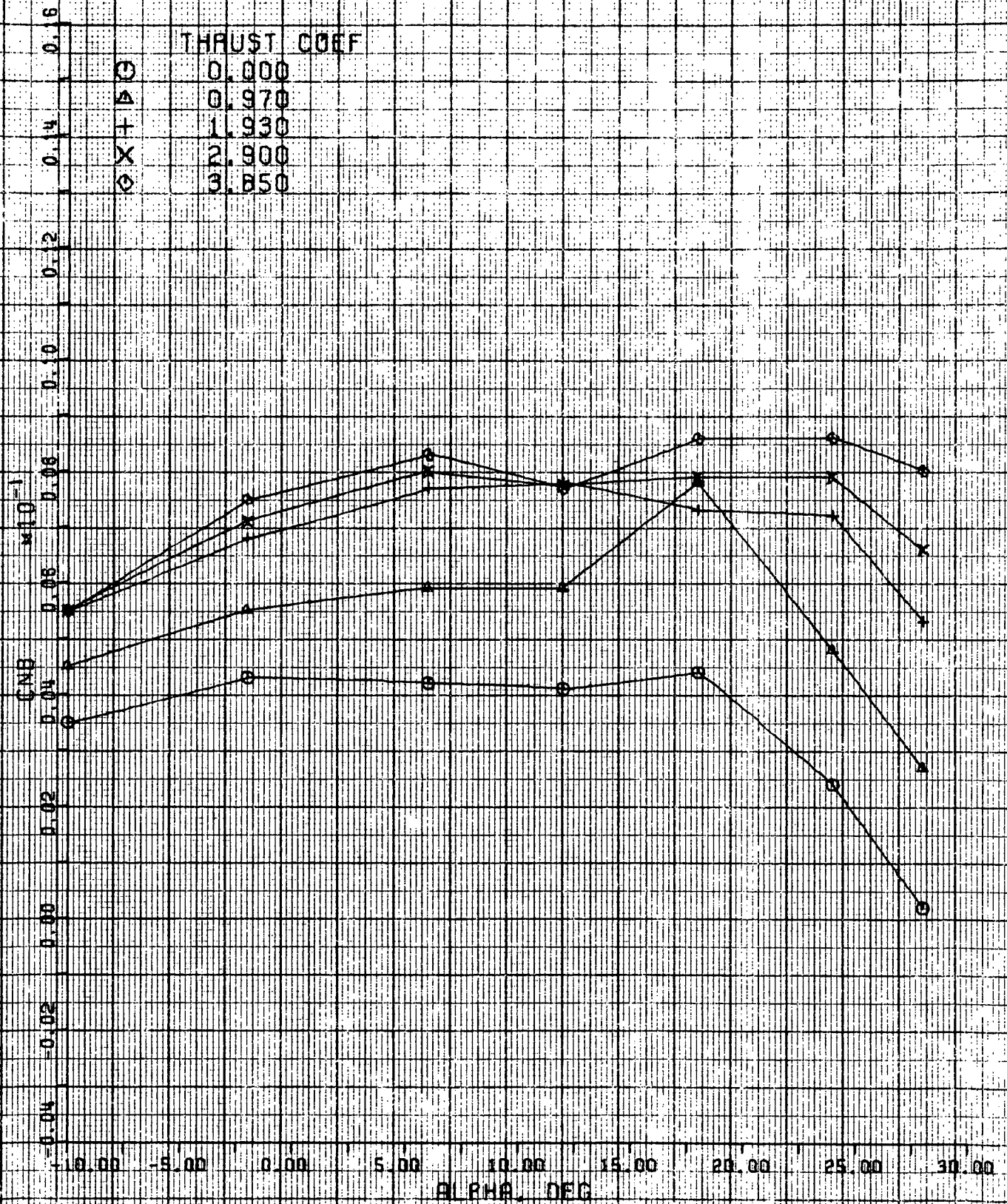


Figure A30

FBF STOL SPREAD ENGINE 4-4-72
 35 DEG FLAP SETTING

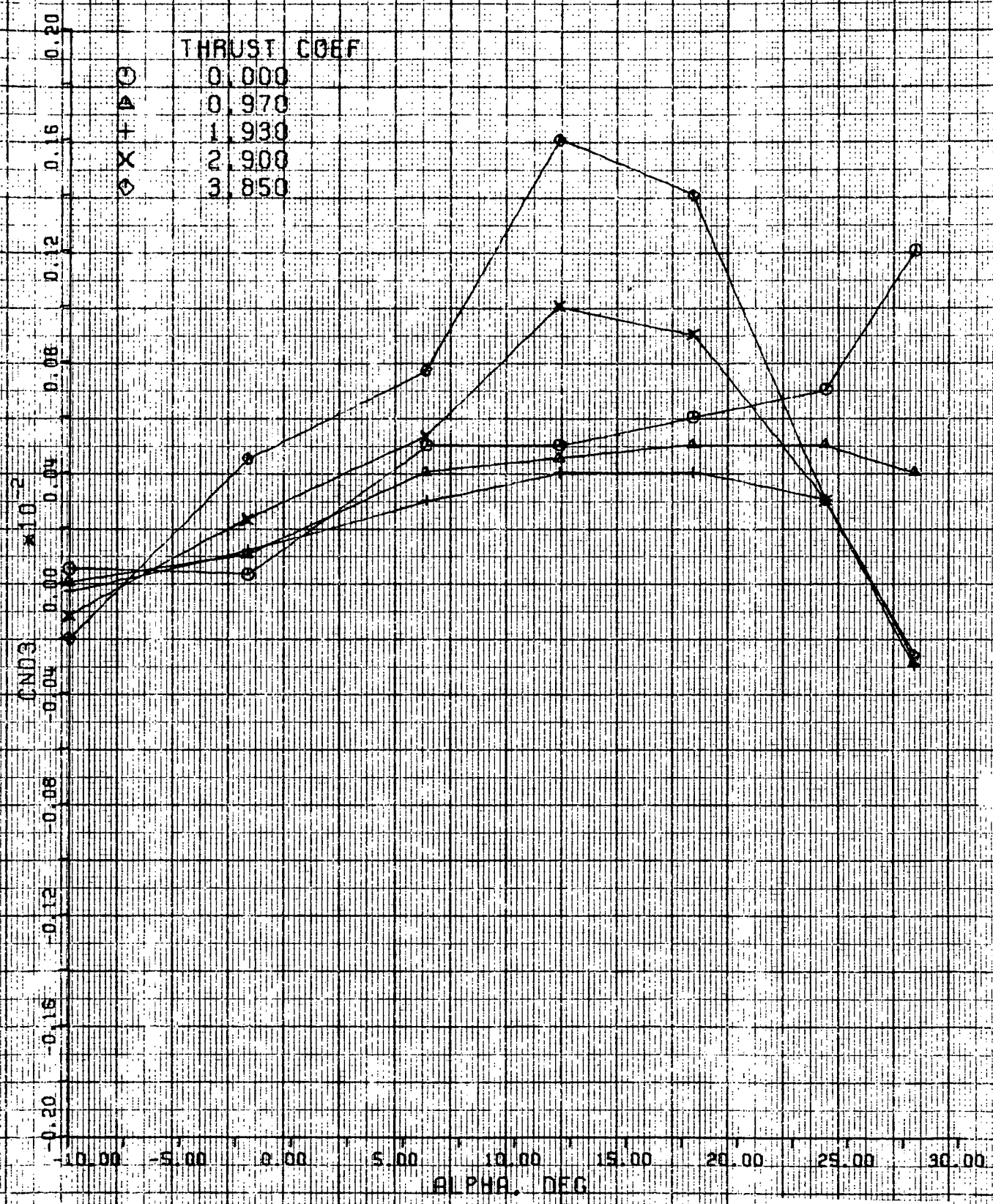


Figure A31

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

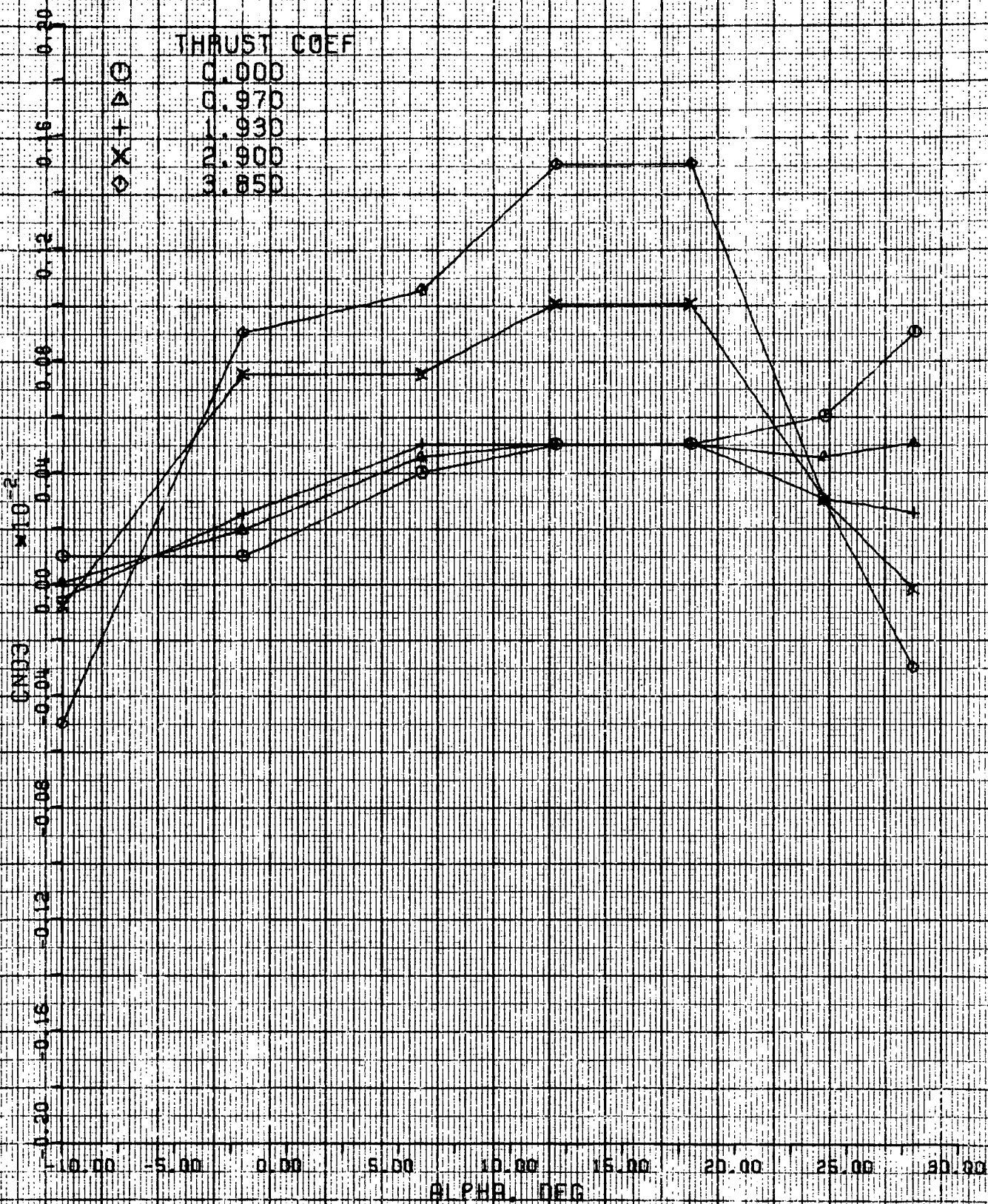


Figure A32

ERF STOL SPREAD ENGINE 4-4-72
 35 DEG FLAP SETTING

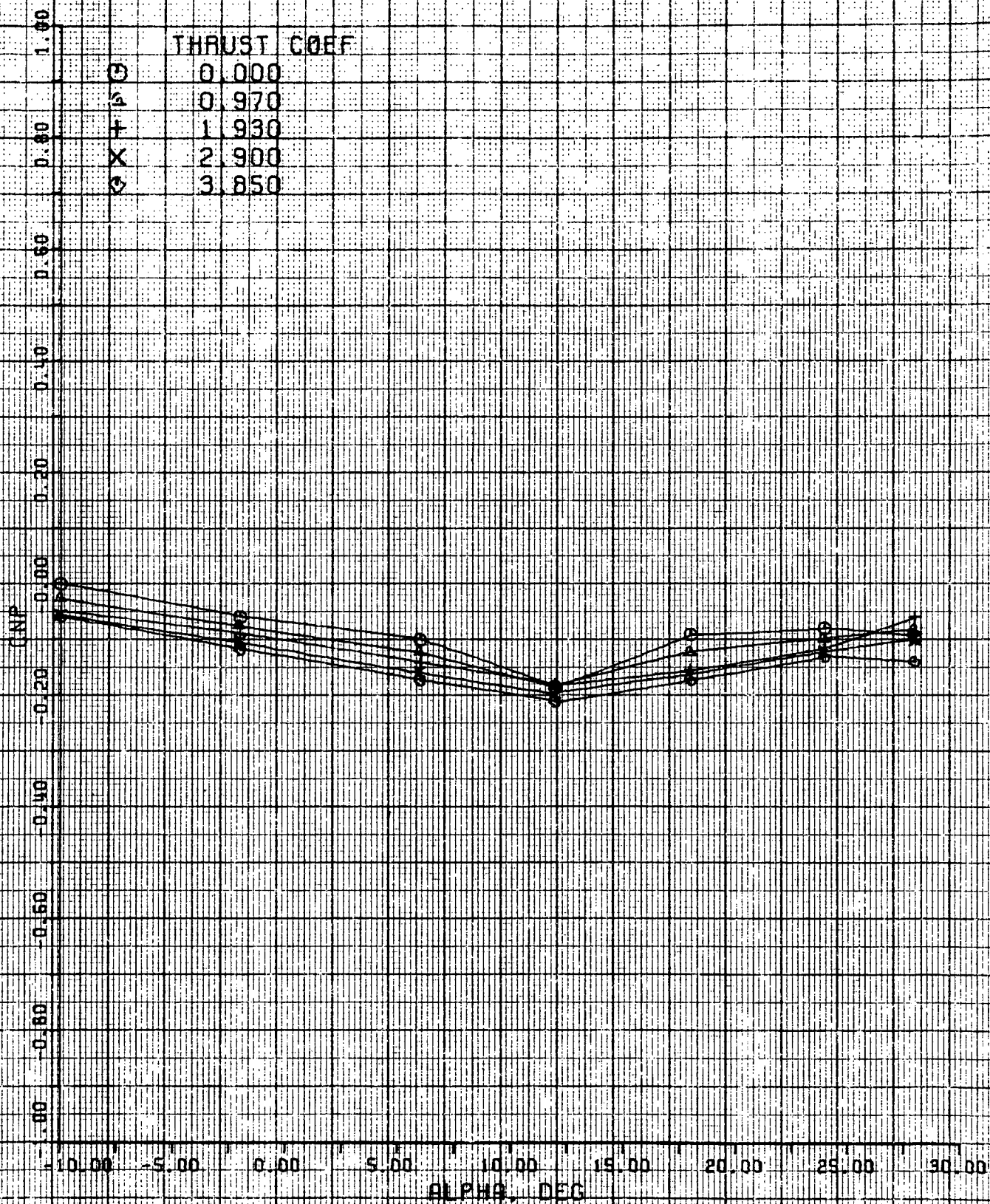


Figure A33

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

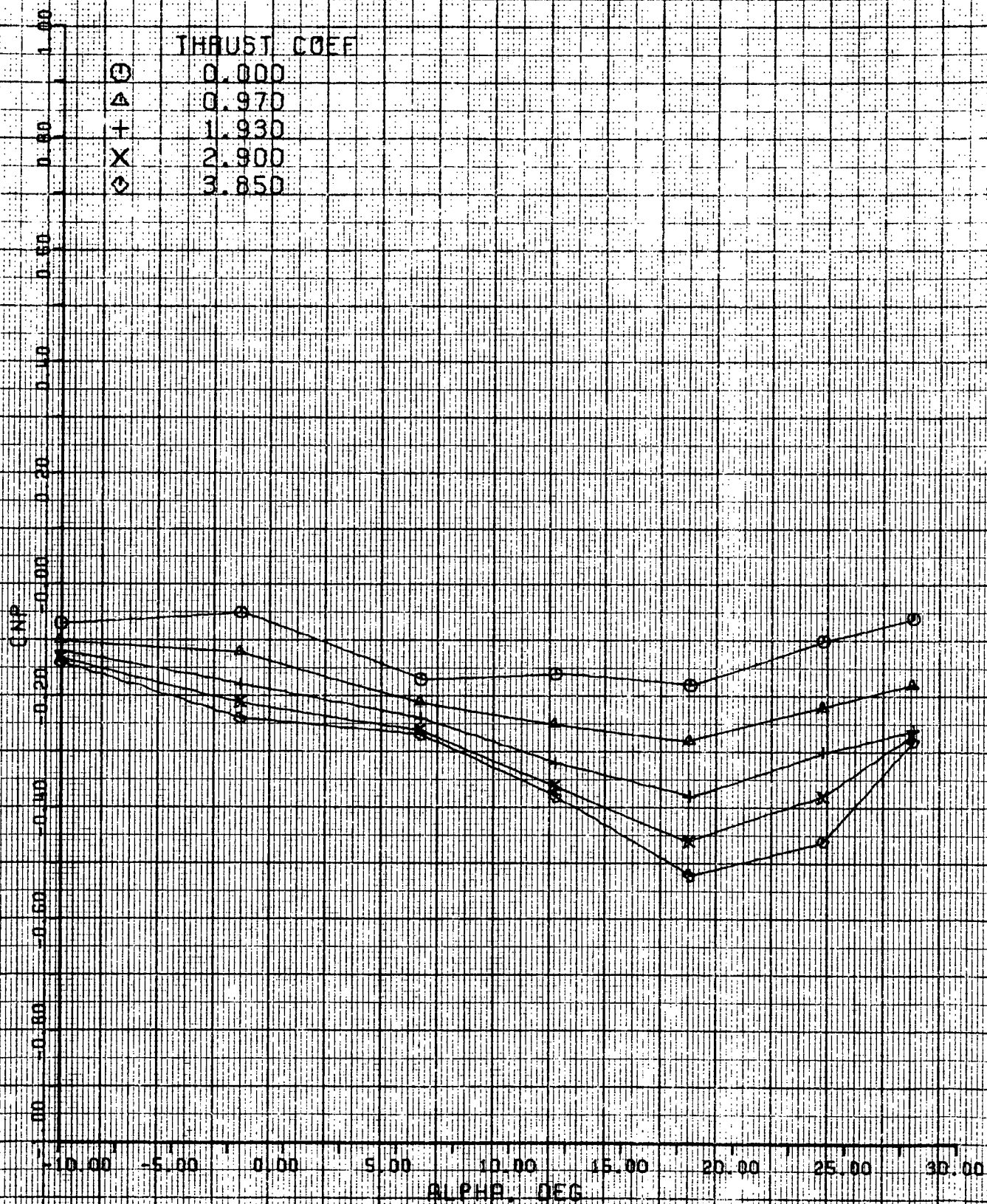


Figure A34

TBR STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

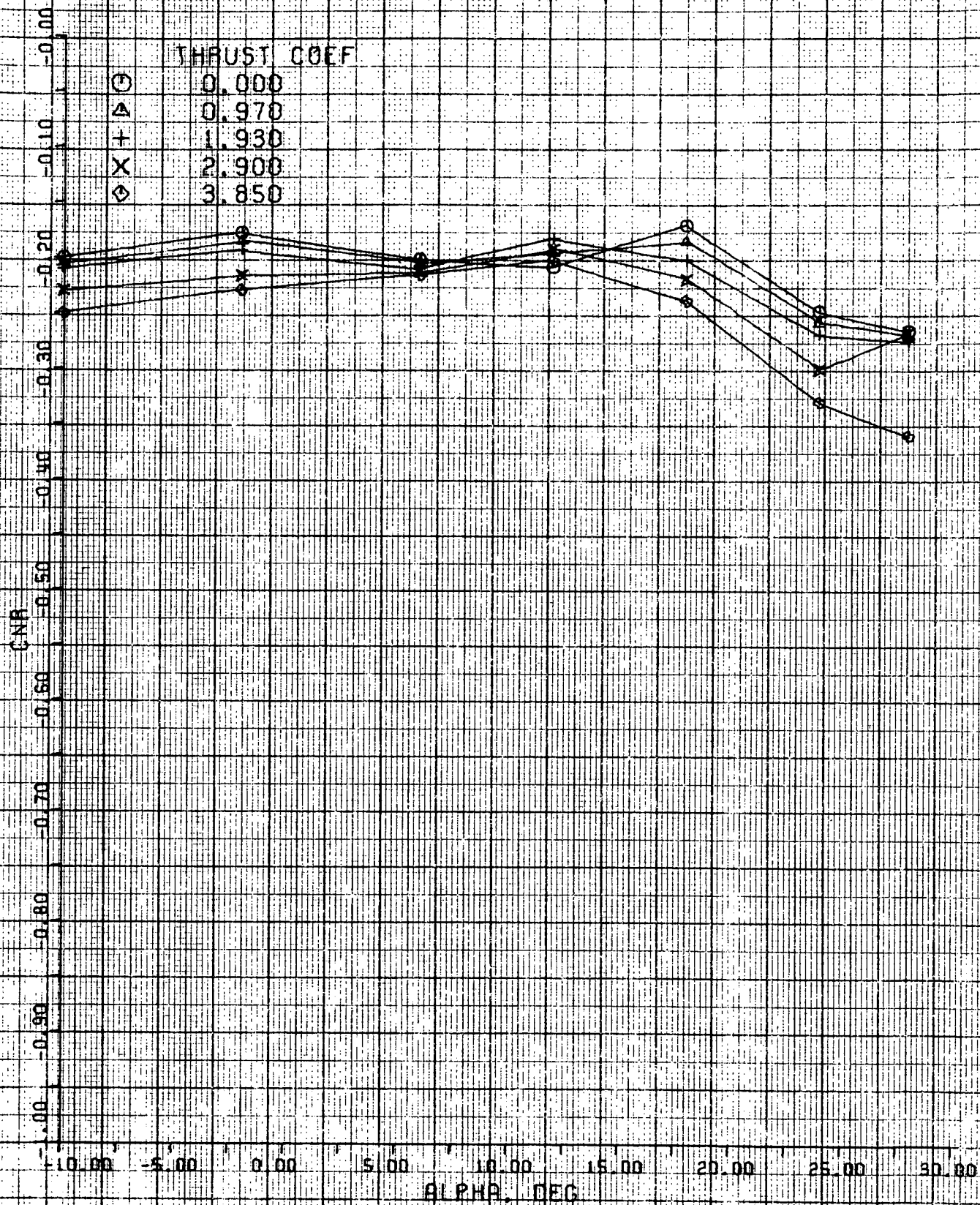


Figure A35

ESF 10L SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

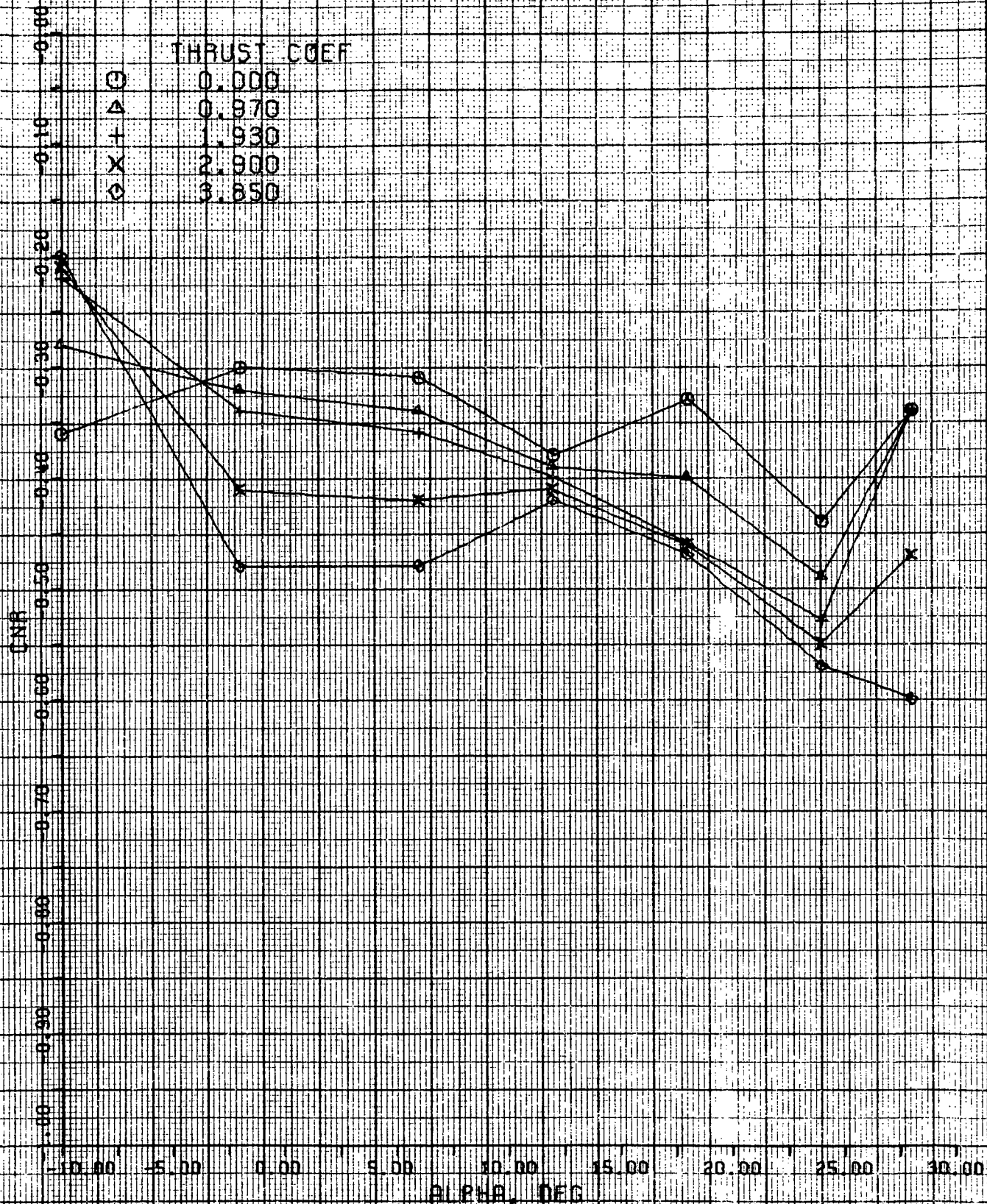


Figure A36

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

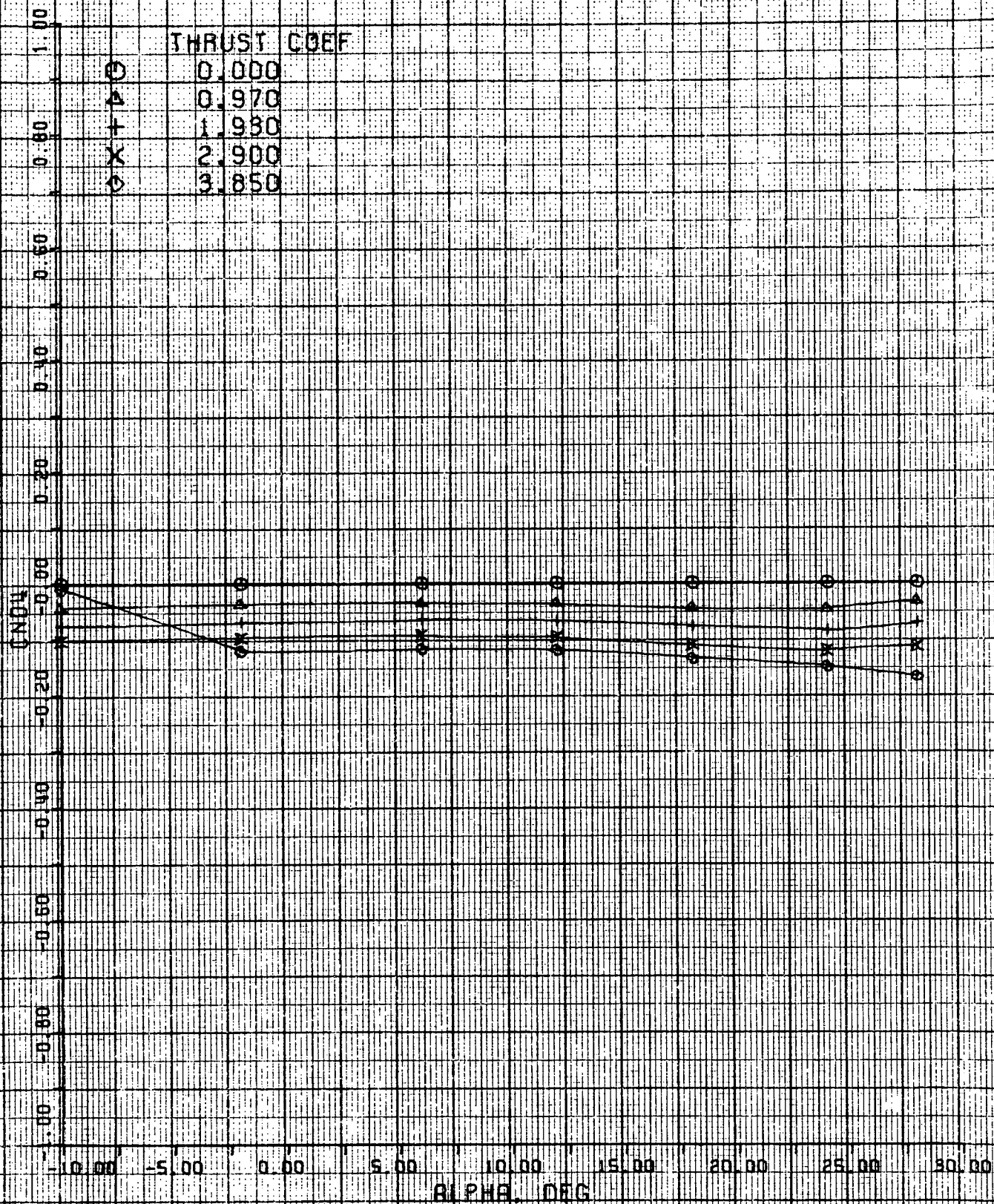


Figure A37

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

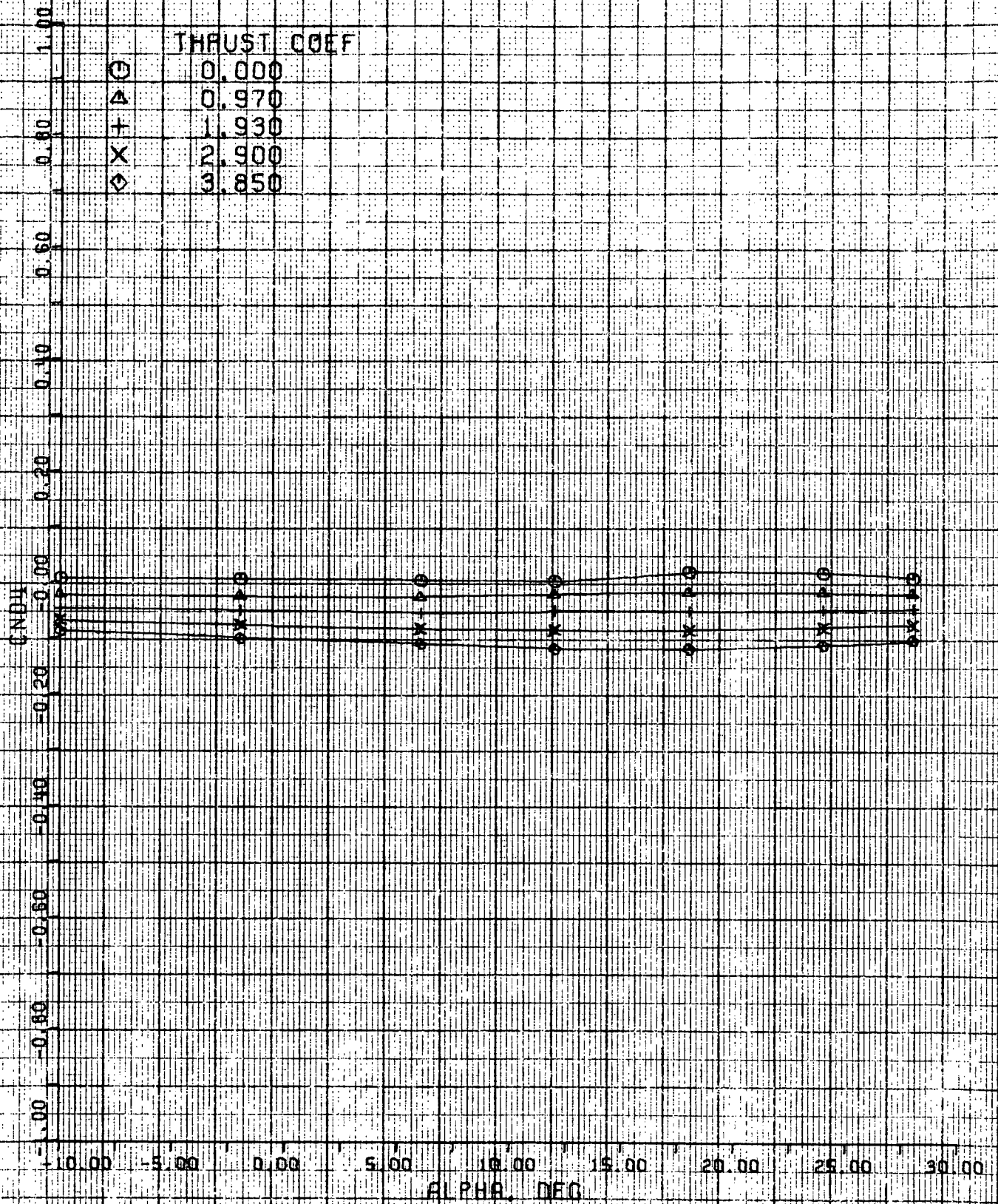


Figure A38

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

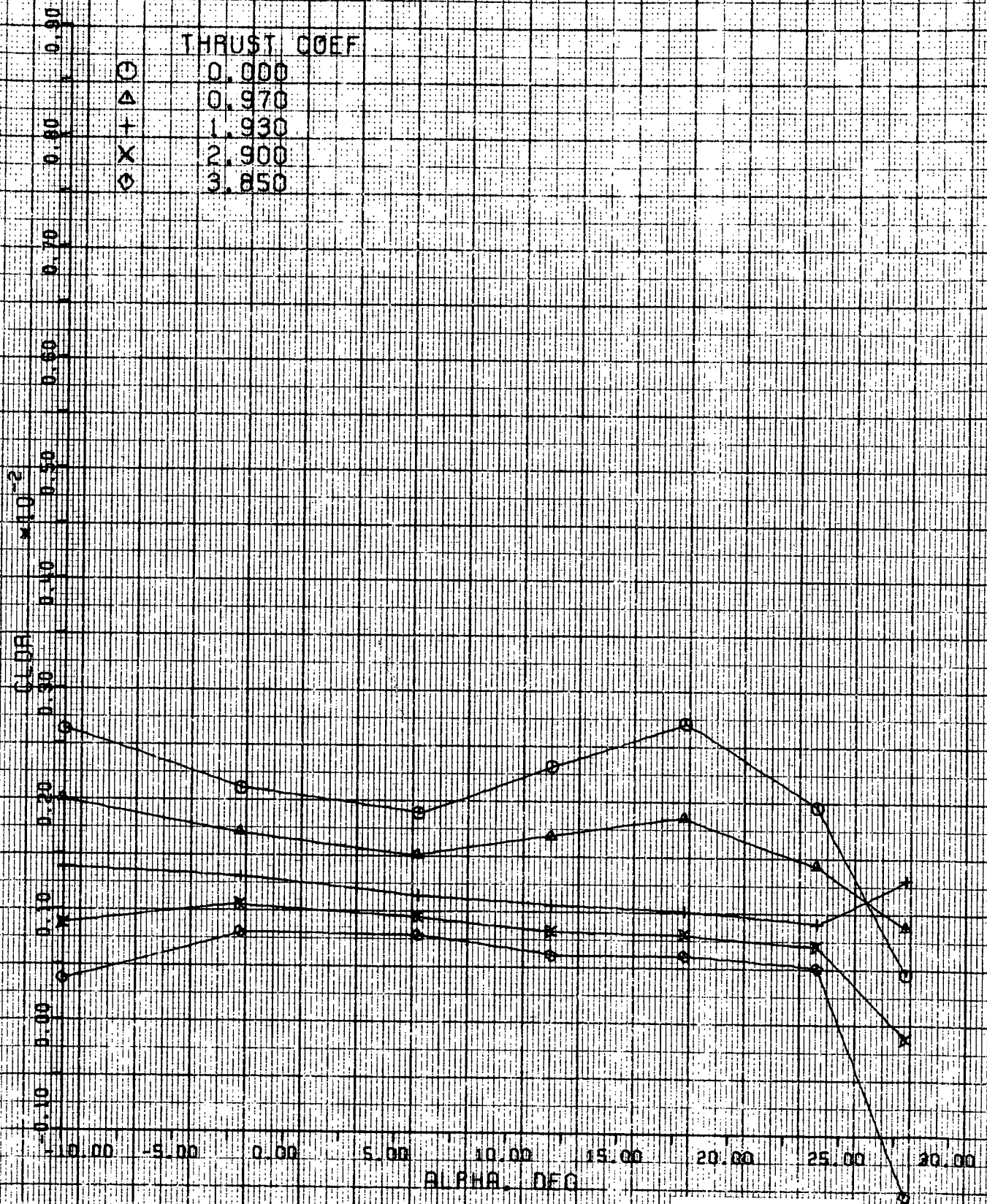


Figure A39

BBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

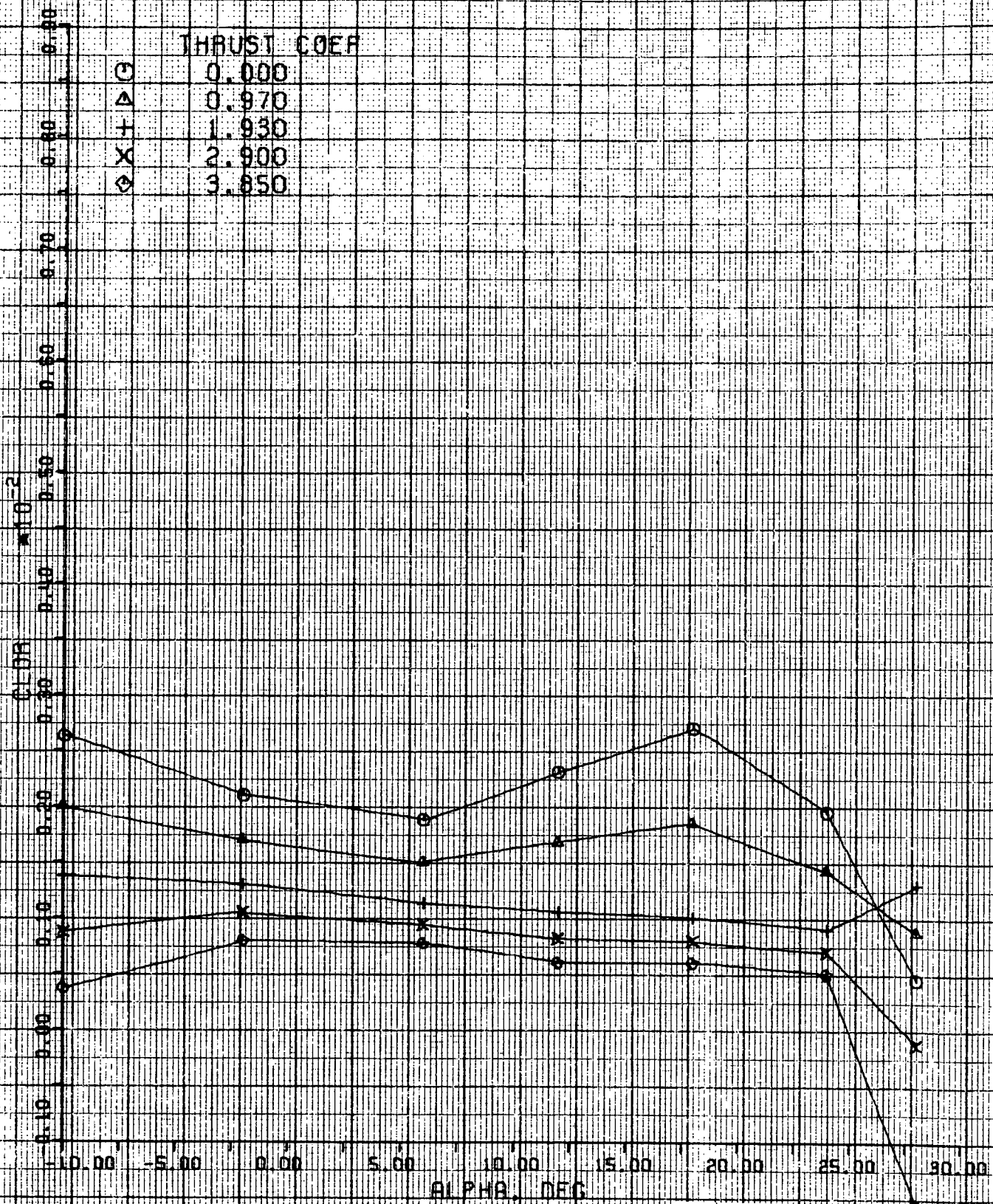


Figure A40

EBF STOL SPREAD ENGINE 4-4-72
85 DEG FLAP SETTING

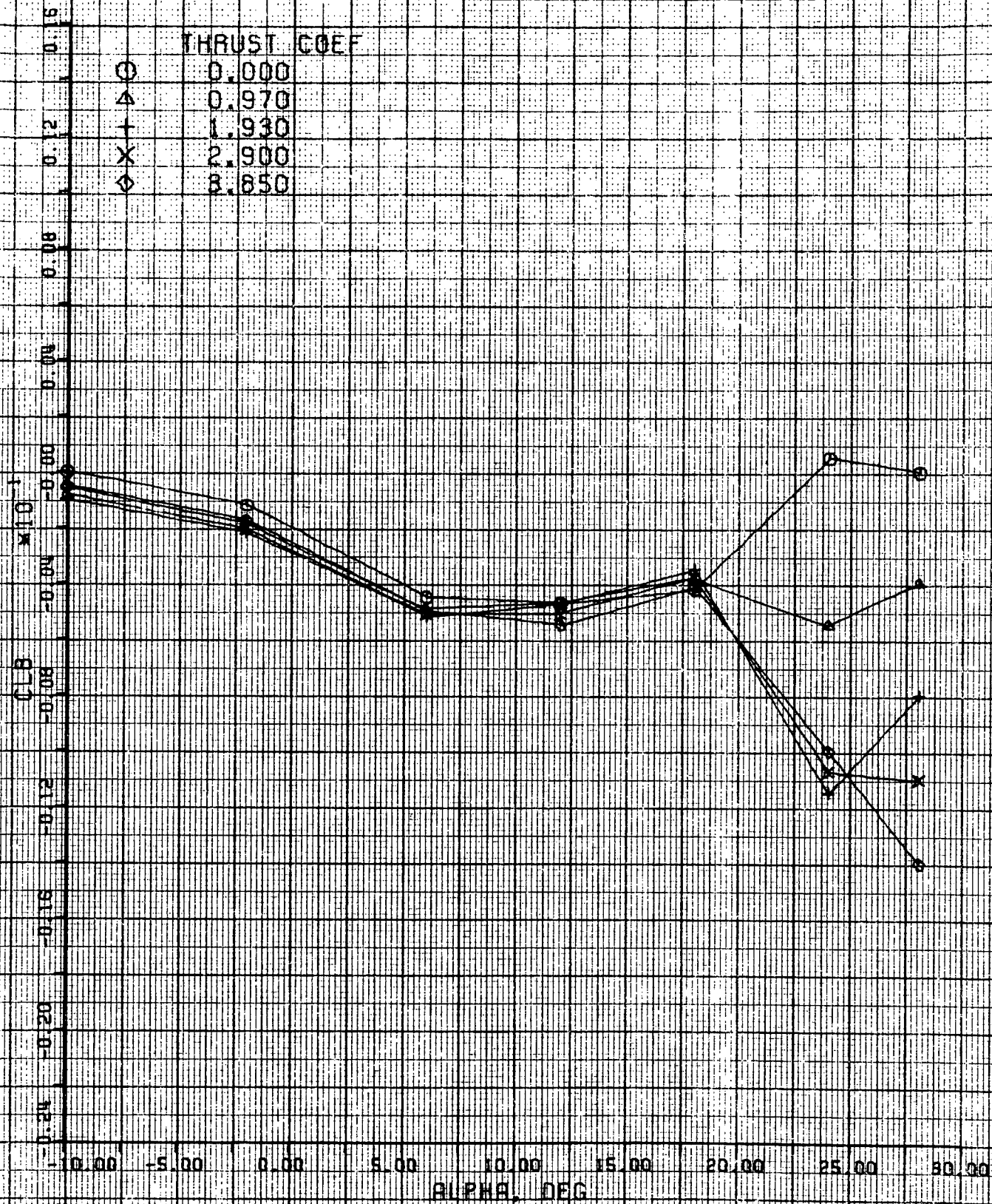


Figure A41

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

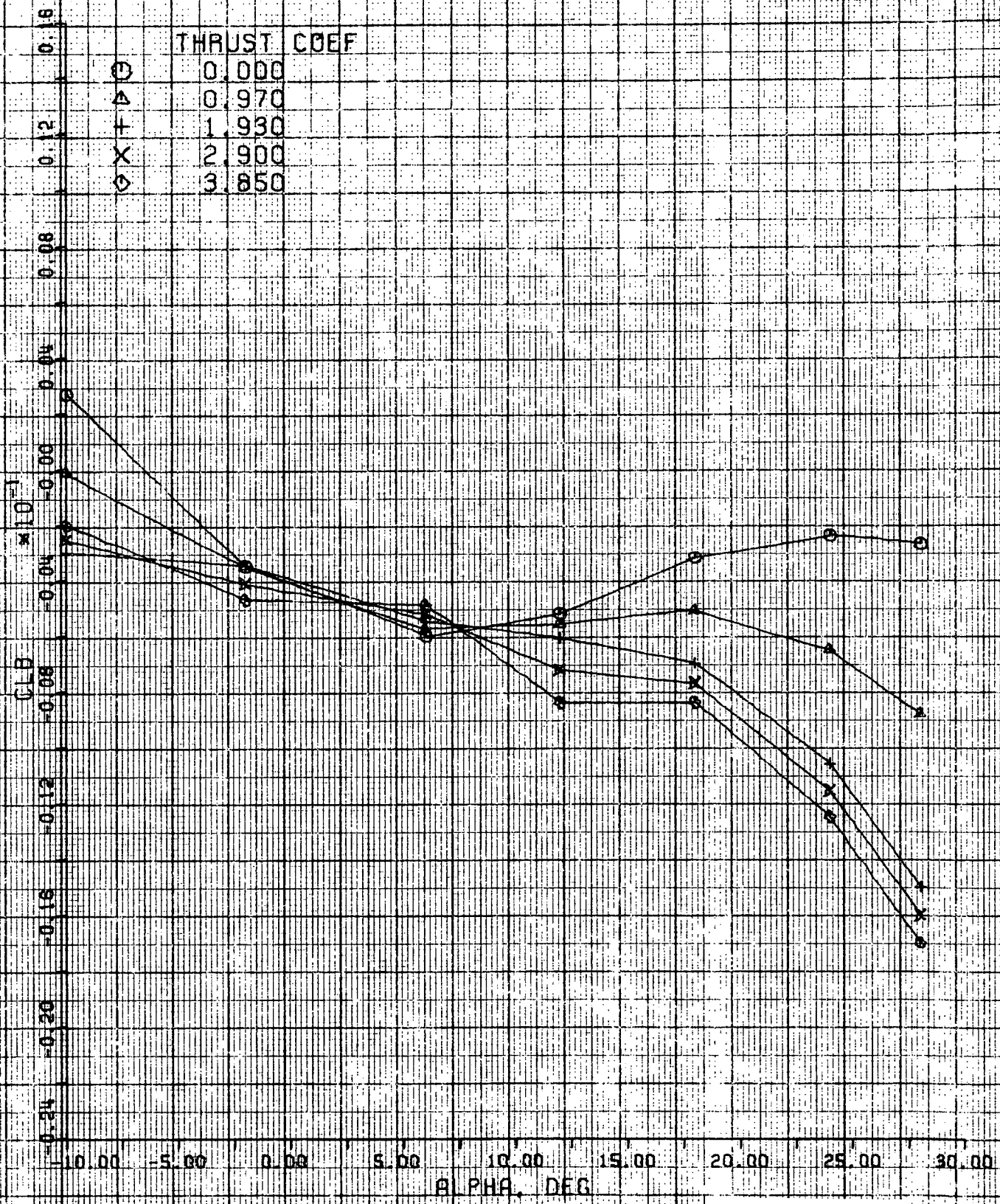


Figure A42

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

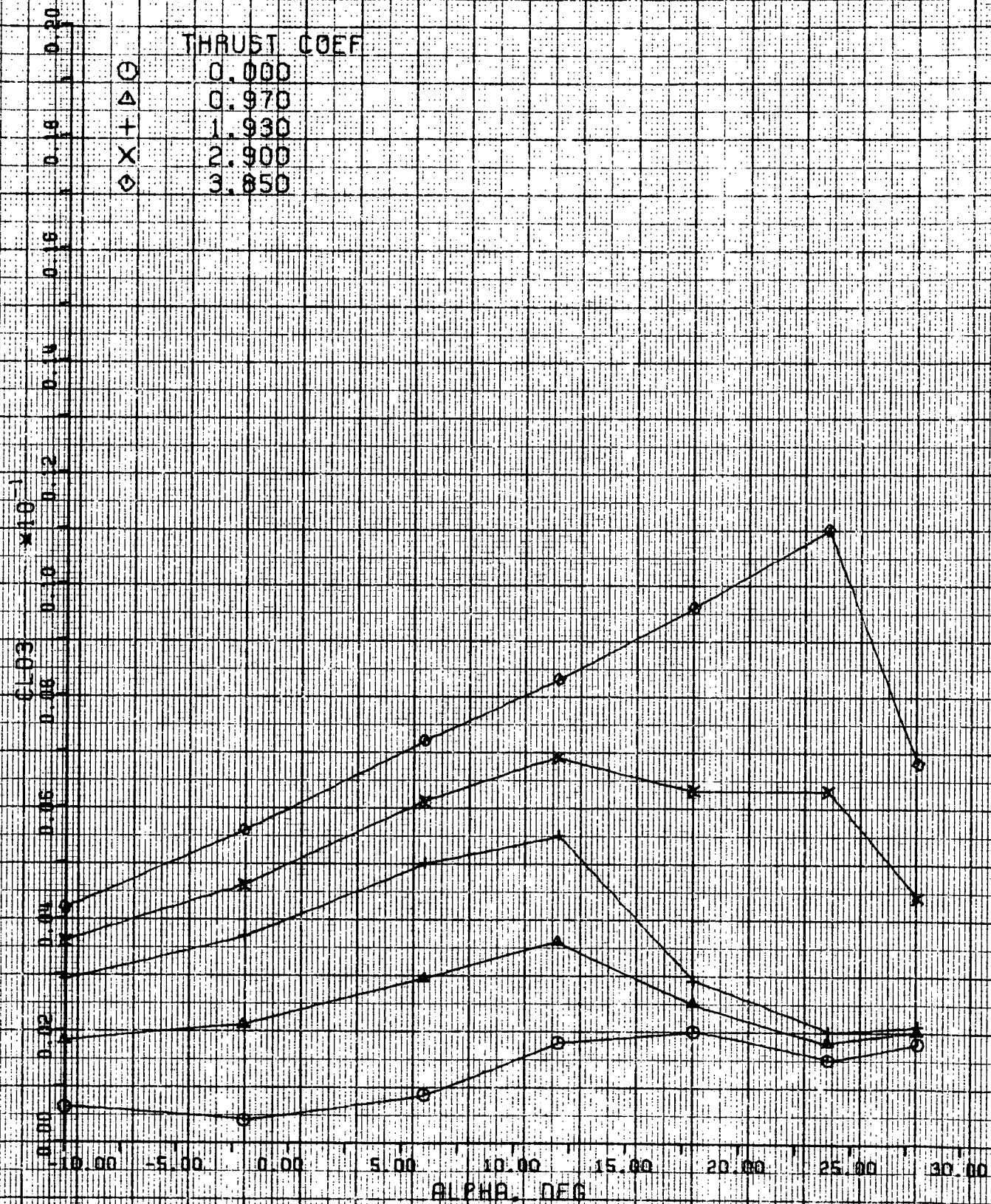


Figure A43

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

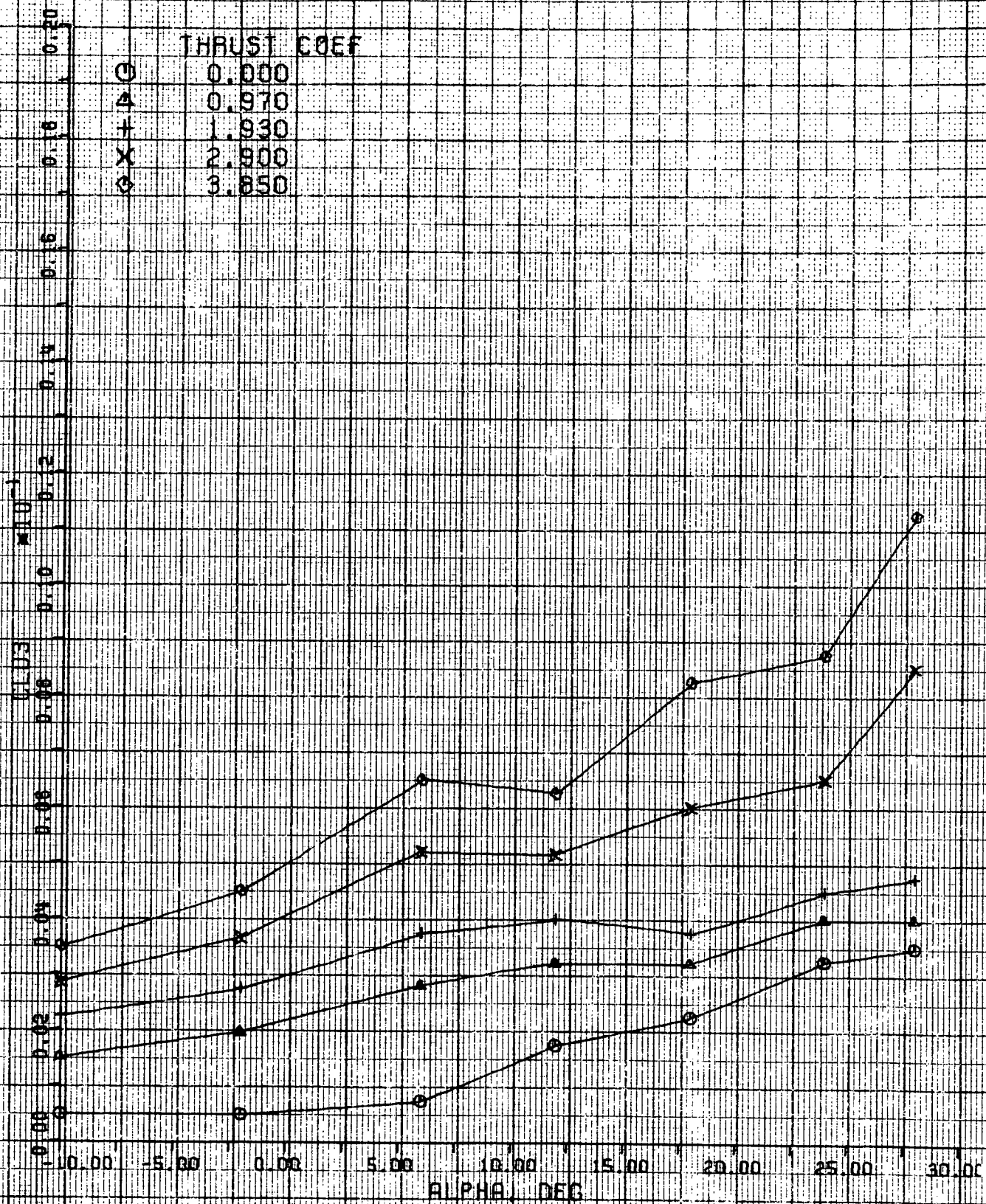


Figure A44

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

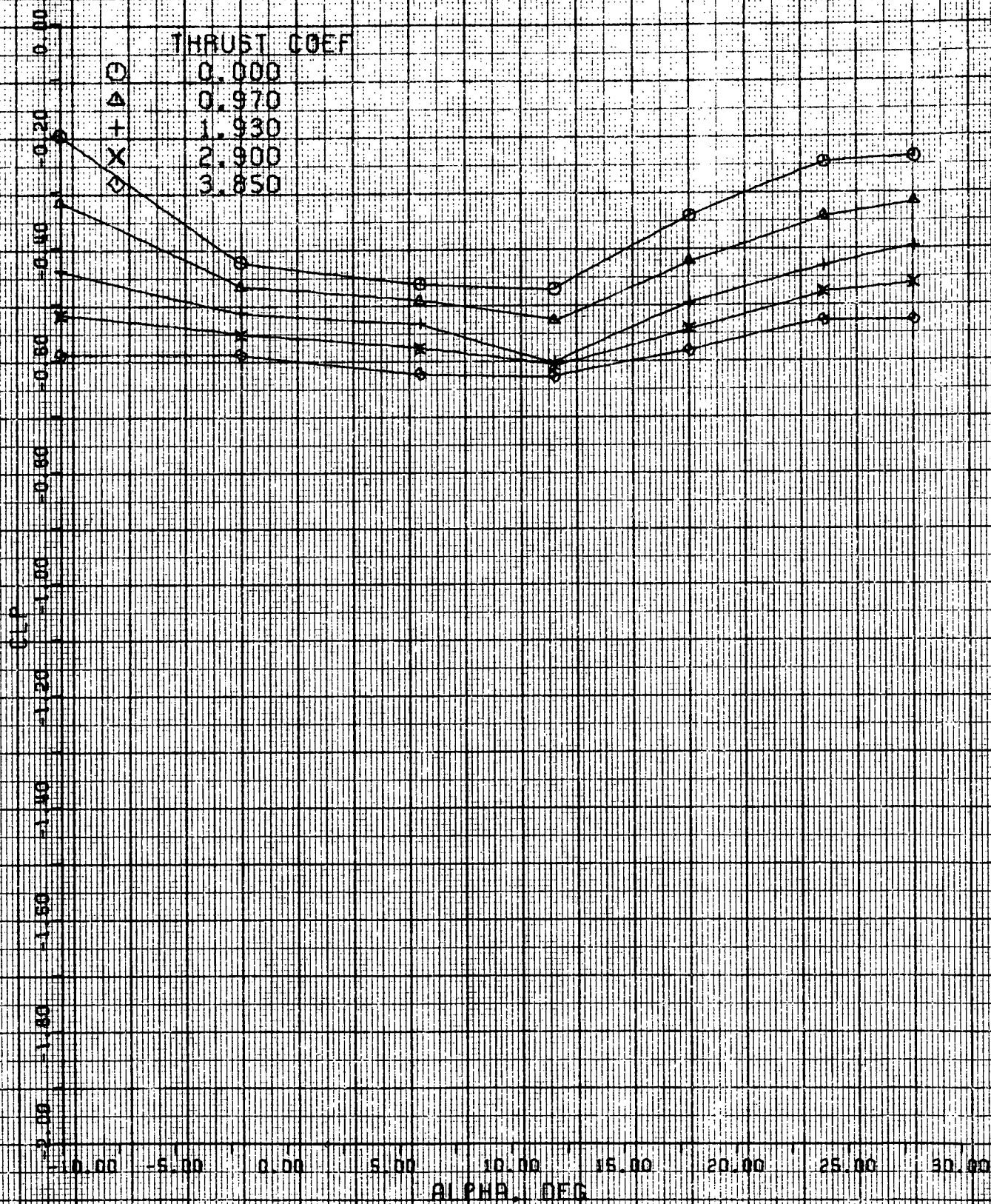


Figure A45

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

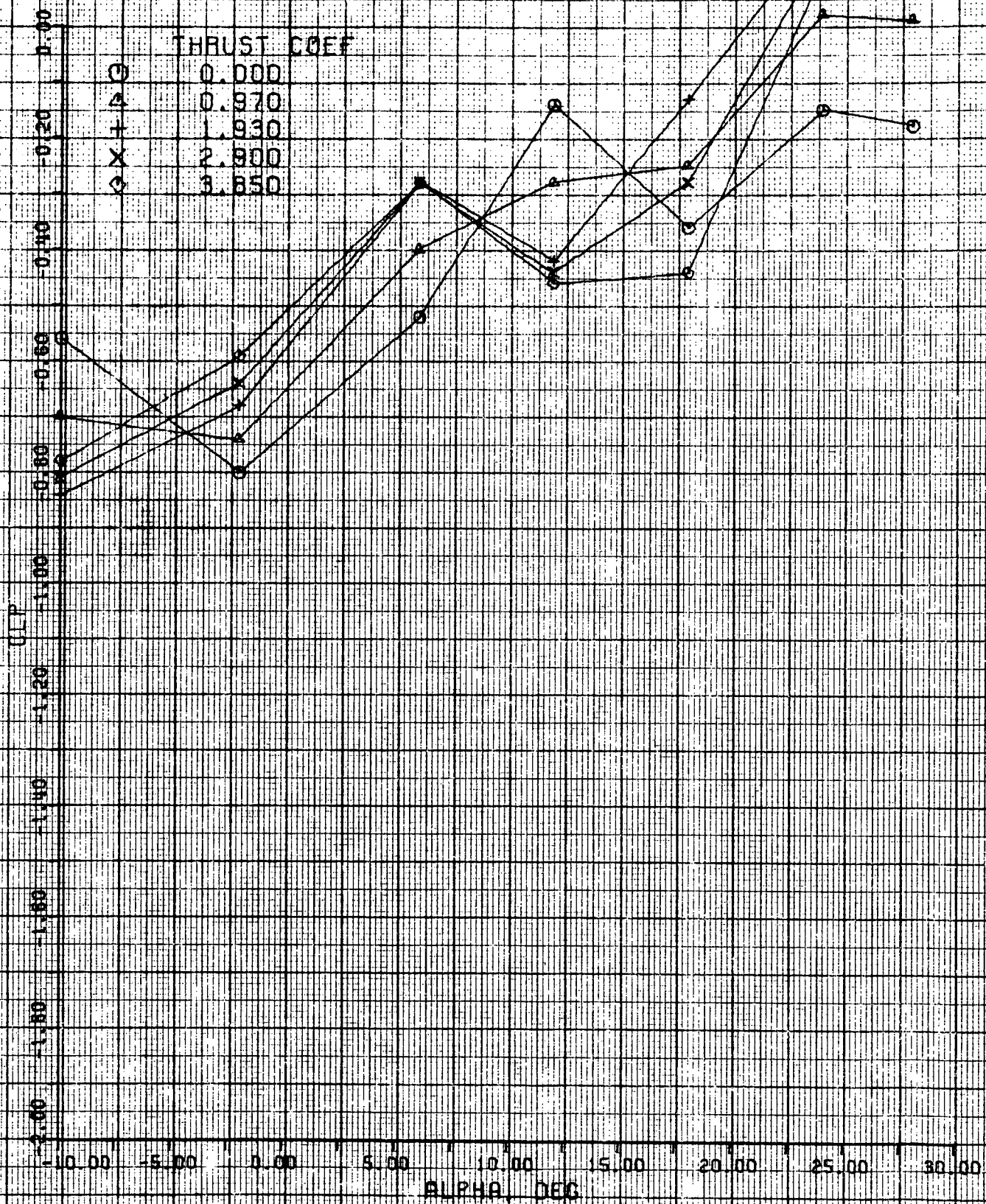


Figure A46

EMF STOL SPREAD ENGINE 1-4-72
35 DEG FLAP SETTING

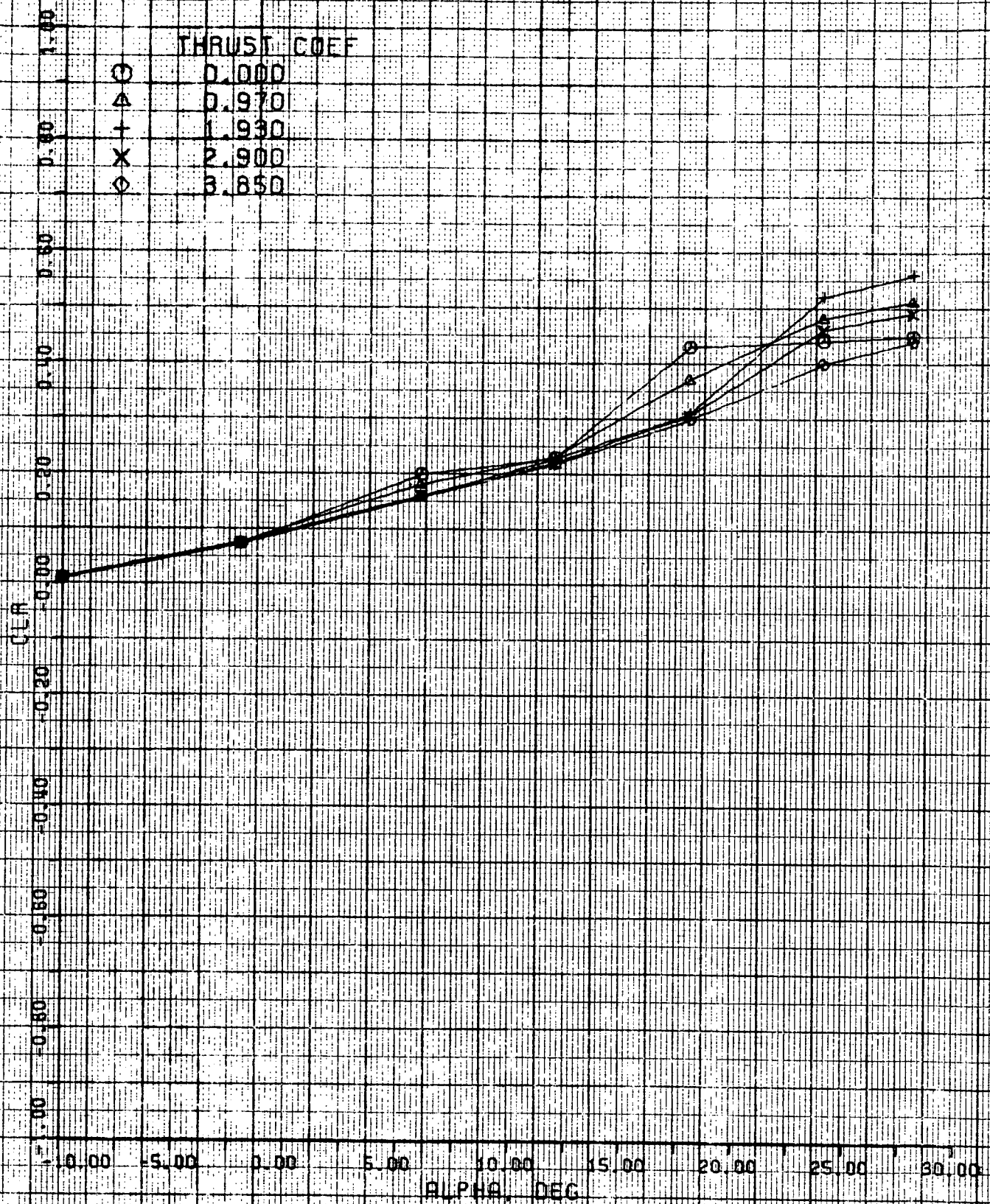


Figure A47

EBF STOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

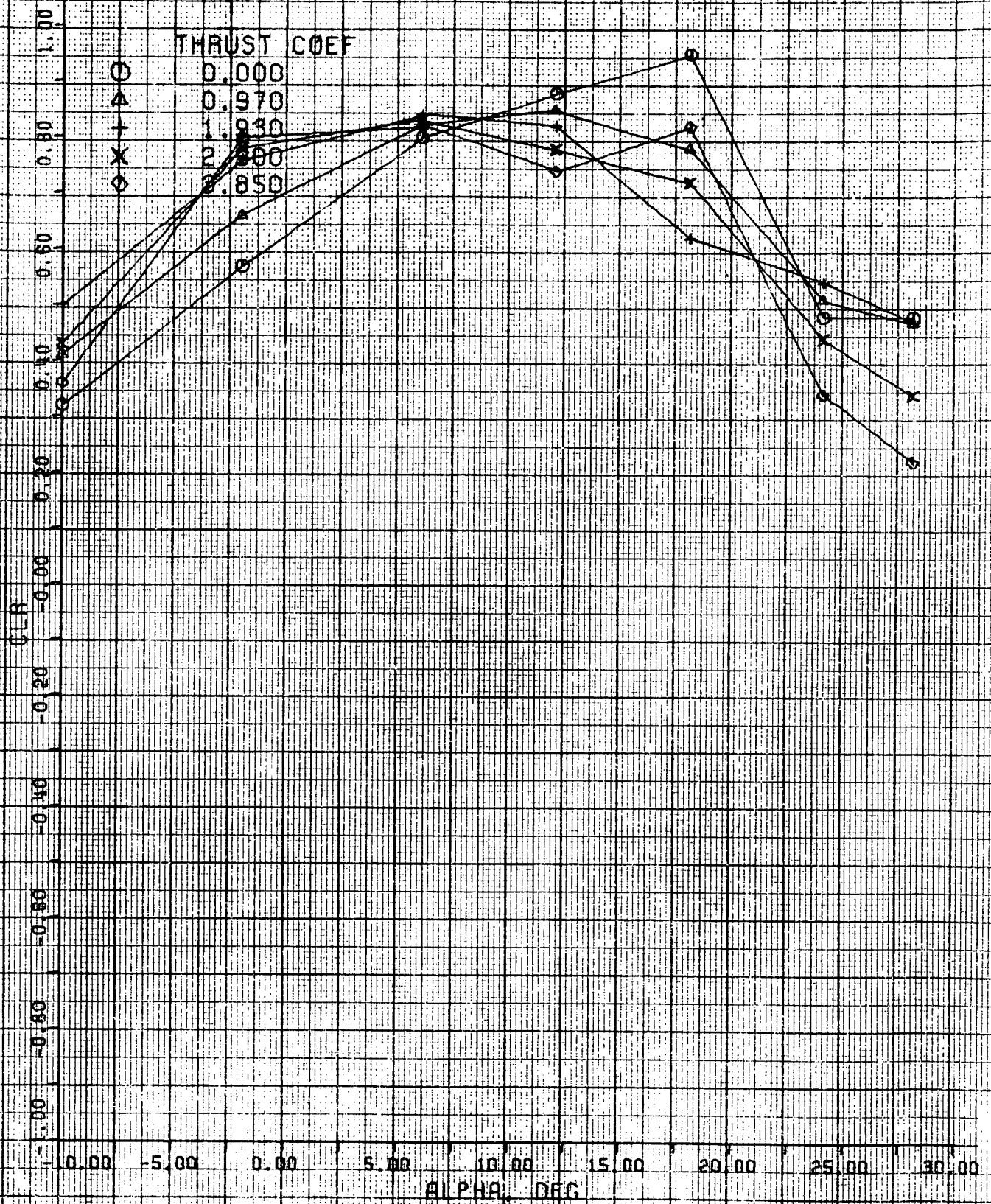


Figure A48

EBF STOL SPREAD ENGINE 4-4-72
35 DEG FLAP SETTING

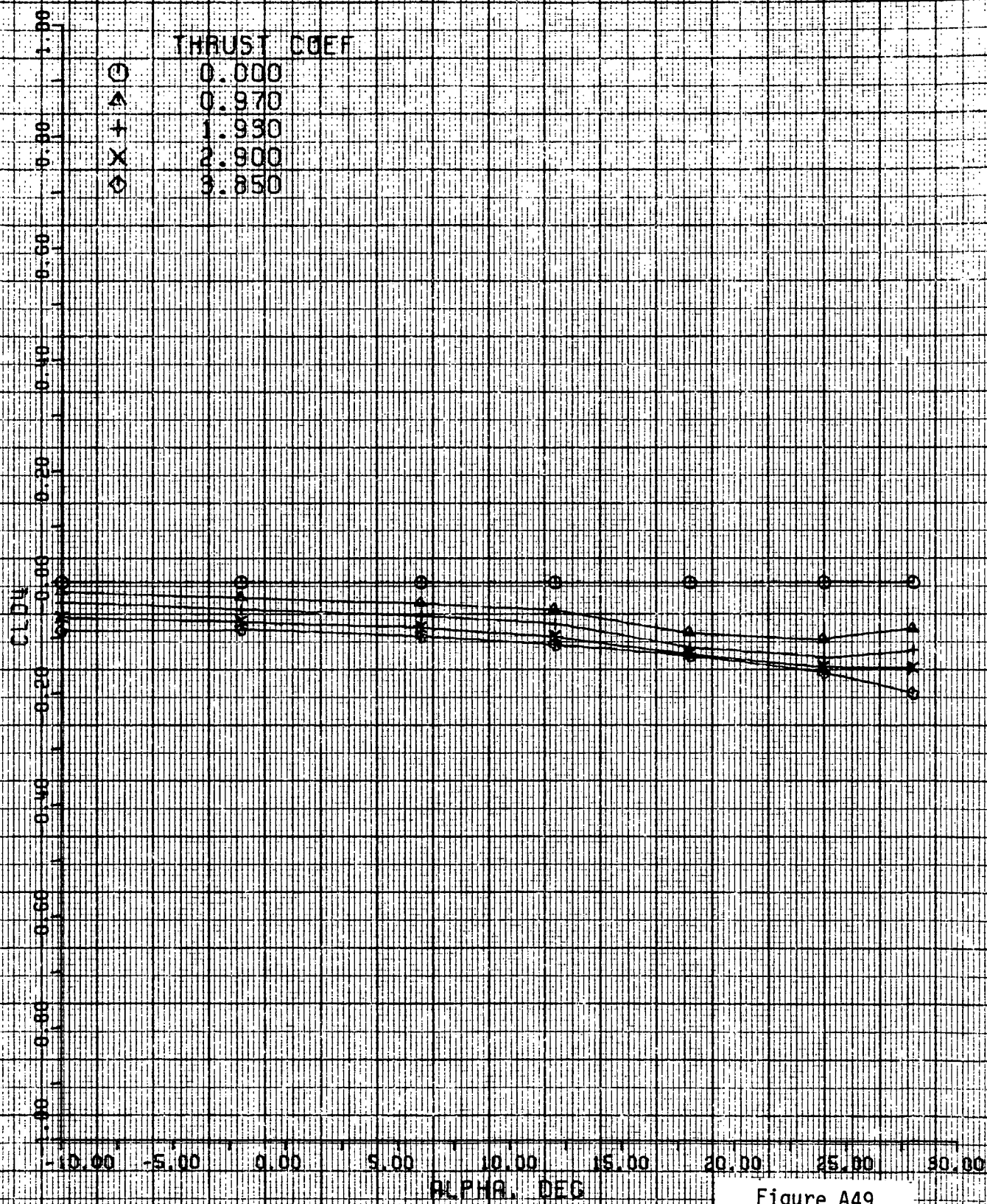


Figure A49

EBF SIOL SPREAD ENGINE 4-4-72
60 DEG FLAP SETTING

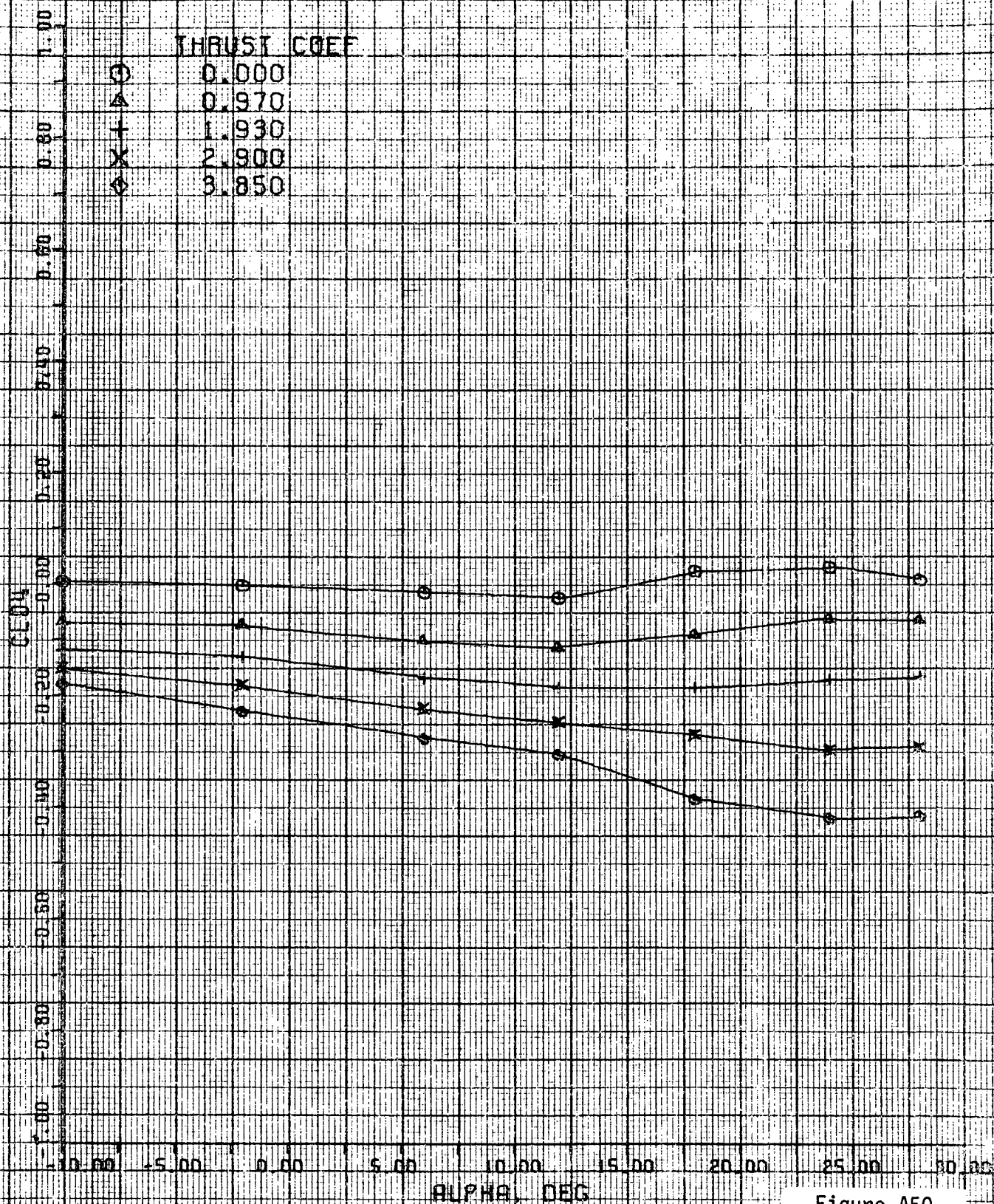


Figure A50